UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL PARK SERVICE

FIELD DIVISION OF FORESTRY

FOREST INSECTS

of the

CALIFORNIA NATIONAL PARKS

PART I

INSECTS AFFECTING SUGAR and PONDEROSA PINE

10—250

U. S. GOVERNMENT PRINTING OFFICE: 1933 6—8215

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INSECTS AFFECTING SUGAR

AND

PONDEROSA PINE

Prepared by the Field Division of Forestry,
National Park Service, in Cooperation with the
Division of Forest Insects U. S. Bureau of Entomology
and Plant Quarantine, and the S.E.R.A., Project 3-F2-678
Berkeley, California
April 1, 1935

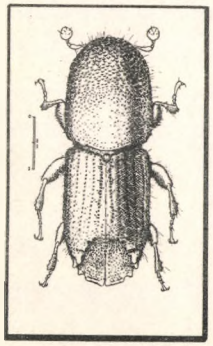
PLATE 1

THE DENDROCTONUS BEETLES AND ONE ENGRAVER BEETLE OF THE NATIONAL PARKS OF CALIFORNIA

A

FIVE SPINED PONDEROSA-PINE ENGRAVER BEETLE

(Ips. confusus Leconte)

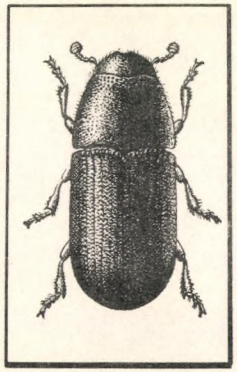


Kills
Ponderosa Pine
Sugar Pine

B

WESTERN PINE BEETLE

(D. brevicomis Lec.)

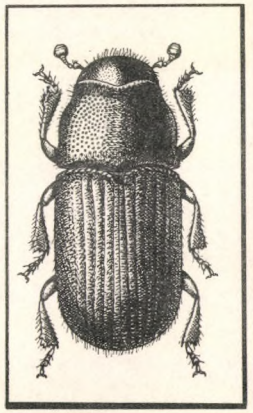


Kills
Ponderosa Pine

C

MOUNTAIN PINE BEETLE

(D. monticolae Hopkins)

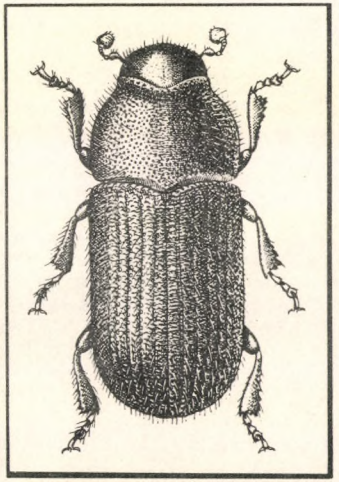


Kills
Ponderosa Pine
Sugar Pine
Lodgepole Pine
White bark Pine
Western White Pine

D

DOUGLAS FIR BEETLE

(D. pseudotsugae Hopk)

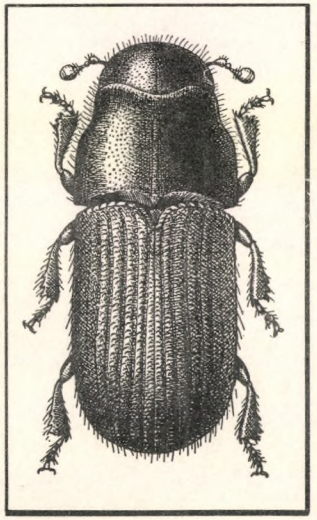


Kills
Douglas Fir

E

JEFFREY PINE BEETLE

(D. jeffreyi Hopk)

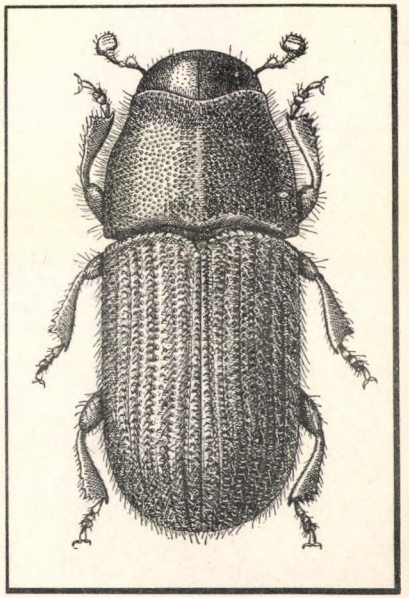


Kills
Jeffrey Pine

F

RED TURPENTINE BEETLE

(D. valens Lec.)



Attacks
Lodgepole Pine
Ponderosa Pine
Sugar Pine
Foxtail Pine
Digger Pine

Much enlarged - Actual size averages 1/5 inch (Ips. at left) to 2/3 inch (D. valens at right)

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AUTHORSHIP AND ACKNOWLEDGMENTS

This manual has been prepared by Donald DeLeon, Field Division of Forestry, National Park Service and the information given here has for the most part been compiled from scattered technical papers, and the typewritten reports of the Office of the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, Berkeley, California. Information has been freely drawn from them. Much of the information, however, is original and is given here for the first time.

Acknowledgment is made to J. M. Miller, in charge of the Berkeley Forest Insect Laboratory of the Bureau of Entomology and Plant Quarantine, for permission to use the data and typewritten reports in the files of the above laboratory and for his constant aid and advice; to J. E. Patterson of the same Bureau for his helpful information and assistance on numerous points; to G. R. Struble of the same Bureau for information concerning the mountain pine beetle and the fir engraver beetle; to R. L. Furniss of the same Bureau for reading the manuscript and for numerous valuable suggestions; to H. L. Person of the California Forest Experiment Station for advice, and to Dr. E. C. Van Dyke of the University of California for numerous determinations. Lastly, F. P. Keen's Bulletin No. 7, "Insect enemies of California pines and their control," State Department of Natural Resources, Division of Forestry, 1929, has been of appreciable help.

All the drawings have been made by S.E.R.A. artists, except Figures E to F, Plate 1 and Figures 42, 48, and 48A, which have been adapted from Hopkins.

INTRODUCTION

The purpose of this manual is to provide semi-technical information on the more common destructive forest insects and those likely to be confused as destructive, for the information of foresters, district rangers, technical foremen, technicians and similarly trained members of the permanent and temporary personnel of the National Parks of California. Familiarity with this information should aid materially in more efficient and intelligent administration of the forests and in better annual insect reports by the district rangers. It should also be of considerable aid to insect control foremen and technicians handling the insect control projects of the Civilian Conservation Corps.

The manual is arranged by host trees, the insects affecting one particular tree being discussed under this tree and discussed a second or third time if they attack a second or a third host. Insects, such as parasites and predators, associated with the destructive insect are discussed in the Appendix under "Biological Control".

AIM OF INSECT CONTROL WORK IN THE PARKS

Destructive insects have been in our forests for past millenia and will, no doubt, be with us for many more to come. We can not hope to exterminate them, nor would this, perhaps, be a wise thing to do if we could. We do hope to prevent extensive outbreaks.

The aim of the National Park Service is to maintain the forests within the park boundaries in conditions uninfluenced by man. At first glance it would seem contrary to these aims to control insect outbreaks or put out forest fires as both of these are natural factors. If insects or fires destroyed only a small portion of the forests and were potentially no menace to large areas, control of either of these factors would not only be unnecessary, but a waste of money. However, both fires and, at times, certain insects are potential enemies of considerable areas of forest, and insects especially, being more dangerous to mature trees. As it is the mature trees of the forest that the public chiefly admires, the Park Service is obliged to protect them by preventing or controlling outbreaks of any destructive insect. It does not, however, do control work where only small areas or proportions of a stand are threatened or where aesthetic values are not at stake.

ARTIFICIAL CONTROL

The methods of making surveys for spotting preparatory to bark beetle control work has been so thoroughly discussed* that there is no need to discuss it here. Actual bark beetle control methods are explained and illustrated in a separate mimeographed bulletin, which can be secured on request from the Superintendent of any of the Parks, or the Field Division of Forestry.

The method of control to be used for any particular insect is mentioned under the insect concerned by hosts.

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* Control of the western pine beetle (Dendroctonus brevicomis). U. S. Forest Service, Portland, Oregon, May 1933. Mimeographed. A few copies are available for distribution, gratis, at the Field Division of Forestry Headquarters, National Park Service, Berkeley, California.

CHARACTERISTICS AND HABITS OF FOREST INSECTS

Forest insects, in general, are our best and most numerous friends and deserve a higher place in our consideration. In number of species they make up probably much more than fifty per cent of all animal life in the Parks. As in other groups of life, however, there are outcasts, so among forest insects are there black sheep which so center one's attention that their much worthier relatives are either overlooked, or considered with suspicion. The black sheep in this case, are, for the most part, little black beetles scarcely a quarter of an inch long that by sheer strength of numbers are capable of attacking and killing large healthy trees, often within a few weeks after the first attack. These beetles are known as bark beetles because they breed in the living tissues of the tree just under the bark.

To return for a moment, to the first sentence. Insects help to provide us with food, flowers, clothes; but these are only small items. In the forests, probably their most important, but least conspicuous role, is to help reduce weakened, dying, and fallen trees back to soil. In these trees, they bore holes and loosen the bark, letting in air, moisture, bacteria, and fungi which help to transform rapidly wood into humus. Without insects, decay is much slower. In some cases we have such examples of very slow decay as in the ghost forests around Tenya Lake, Yosemite National Park. There the destructive insects killed off the timber so rapidly that the wood-reducing insects were probably not in sufficient numbers to breed in all the trees when they first died, and as the dead trees dried out conditions became unfavorable for most insect and fungus development. Thus the majority of these trees, killed from 1907 to 1916 are standing today.

Carrion inhabiting insects are also of value in helping to rid the forest of dead animals. Without insects to feed upon, we would probably have few forest-inhabiting birds. Most likely insects are of more value in supporting insectivorous birdlife, than these birds are in reducing the numbers of noxious insects.

The growing period of all higher insects is during the larval stage, Fig. 1, 2, 43, 48, etc., which is the stage between the egg and pupa, Fig. 48A. When a larva, which is Latin for mask, becomes too large for its skin it molts to a roomier one. Some insects molt but once; others have been known to molt as many as twenty times. The number of molts of bark beetle larvae, varies with the species, and is probably not entirely constant within a species. Not many kinds have been followed through; those that have, molt from four to six times. Upon completion of growth, the larva sheds its skin again, assuming a form known as the pupa (Latin for infant done up in swaddling clothes). No feeding is done during this stage, which lasts, generally, from nine to fourteen days. Considerable internal changes take place, however, and with the rupture of the pupal skin the adult beetle crawls out. Its external covering is still soft, and light brown, and it is several days, often considerably longer, before the "skin" or cuticula hardens enabling the beetle to crawl around.

It might be well to emphasize here, that once an insect has reached the adult, i.e. winged stage, as a fly, beetle, moth, wasp, all growth in size or change in appearance has ceased. The smallest fly, beetle, or moth never grows a fraction larger.

There are about twenty different genera of bark beetles within the National Parks of California, but only two of these (Ips and Dendroctonus) can be considered of much potential danger and of the two, Dendroctonus is by far the most aggressive. The members of both of these genera attack conifers only. There are 24 known species of Dendroctonus in the world, and of these, 23 occur in North America, 19 of them are found only in the United States, 13 range west of the Rockies, 5 species are found in Yosemite and Lassen Volcanic, and 4 in General Grant and Sequoia National Parks. They breed only in various kinds of pine, spruce, and larch. Each species is confined for the most part, to one, two, or three hosts and consequently is limited in distribution, except D. valens which breeds in most pines and ranges from Maine to California and from Labrador and Alaska to Yucatan. It is also the largest species. Twenty-four Ips are recorded from the United States; 7 can be found in Yosemite and Sequoia National Parks. The various species in the Sierra breed only in pine.

Bark beetles are cylindrical, grey, brown, or black; never more than three eighths of an inch long. The antennae are short, elbowed, and terminated with a club of various shapes*. In habits, they are divisible into two main categories: The ambrosia beetles** and the cambium beetles. The former bore into solid wood and live only on the strands (ambrosia) of fungi which they bring in and cultivate. Each species feeds only on a particular kind of fungus, regardless of what host it attacks. One group of these beetles, like Platypus and Xyleborus (p. 63), grows fungi, the strands of which end in swollen cells or conidia, lay their eggs loose in the galleries, and the larvae on hatching feed socially in the same channels as the adults. The other group, like Gnathotrichus and Trypodendron (p. 63), makes "cradles" on the upper and lower sides of the galleries in which the egg is laid and the developing larva feeds upon a fungus that grows in long tangled bead-like chains.

The ambrosia does not grow by accident in the galleries of the beetles. To quote Hubbard, "Its origin is entirely under the control of the insect. It is started by the mother beetle upon a carefully packed bed or layer of chips, sometimes near the entrance, in the bark, but generally at the end of a branch gallery in the wood. In some species, the ambrosia is grown only in certain brood chambers of peculiar construction. In others it is propagated in beds, near the cradles of the larvae. The excrement of the larvae is used in some and probably in all the species to form new beds or layers for the propagation of the fungus."

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* See Figure 42 at back of this handbook for bark beetle with parts named.

** Hubbard, H. G. The ambrosia beetles of the United States. Illus. U. S. D. A. Bulletin #7 N. S. 1897. p. 9-30.

There may be some ancient relationship between the ambrosia of the ambrosia beetles and the blue stain normally found associated with the true bark beetles. The spores of blue staining fungi are carried both by Dendroctonus and Ips when they attack a tree and it has been pointed out by Craighead* and later other workers, that these fungi probably contribute to the rapid death of the trees attacked. It has also been suggested by Craighead that there is a symbiotic relationship between the fungi and these beetles. The fungus associated with Dendroctonus brevicomis is Ceratostomella pini Muench; the one associated with several species of Ips is Ceratostomella ips Rumbold. Both of these fungi are closely related to Ceratostomella ulmi (Schwarz), the European fungus causing the Dutch elm disease that has been found to be so deadly to the elms in the East and which is likewise introduced, in part, at least, by a bark beetle, Scolytus multistriatus.

The cambium beetles or true bark beetles, mine out, or feed, with a few exceptions, on only the growing or recently growing portion of the tree between the wood and the bark. Their galleries usually groove the wood to a varying degree. Each species makes galleries which are, for the most part, so characteristic that by merely looking at their shape one can tell by which beetle they were made. Some species are chiefly monogamous, a male and a female inhabiting a single burrow, as most of the Dendroctonus and Scolytus, others are bigamous, still others are polygamous as Ips, Pityophthorus, Pityogenes. Among the bark beetles, the female as far as is known, starts and makes her own separate gallery in which the eggs are laid. Among the polygamous species these egg-galleries branch off from a central cavity or nuptual chamber, as it is called, which is first excavated by the male. As many as nine galleries have been counted radiating from a single nuptual chamber.

Bark beetle larvae (fig. 48, 50) are always whitish or ivory in color, except the head which is usually a shade of brown. In some species the head is a very dark brown (Pseudohylesinus), in others (Scolytus), it is nearly the color of the body except towards the mandibles. Legs are never present on the body, which is practically hairless, more or less round in cross section, and usually considerably curved. There are thirteen body segments, the last of which is poorly developed and obscure, but secondary folds make it appear as though there were many more. Some kinds have the thorax (first three body segments) considerably larger than the rest of the body (Scolytus) in others the body is nearly uniform in size (Dendroctonus).

* Craighead, F. C. Interrelation of tree-killing bark beetles (Dendroctonus) and blue stains. Jl. of Forestry 26: 886-887. 1928

KEY
TO THE
INSECTS AFFECTING THE CONES
OF
SUGAR AND PONDEROSA PINE

Larvae

1. Larvae with prolegs on abdomen (fig. 1, 2) Caterpillars 2
1. Larvae without prolegs on abdomen (fig. 43, 48, 49) 5

2. Larvae pinkish-red . . . . . Gelechia, p. 5, 51
2. Larvae not as above 3

3. Larvae mining in pith . . . . . Laspeyresia, p. 51
3. Larvae feeding in outer scales (Dioryctria) 4

4. Hairs on body long, distinct, over 5 times diameter of spiracles . . . . . D. abietella, p. 4, 51
4. Hairs on body short, rarely twice diameter of spiracles . . . . . D. xanthoenebares, p. 51

5. Legs present on thorax, body hairy . . . . . Ernobius, p. 4, 50
5. Legs absent 6

6. First segment behind head greatly enlarged and flattened . . . . . Chrysophana, p. 43
6. First segment behind head not as above 7

7. Head distinct, brown; body curved, "wrinkled" . . Conophthorus, p. 3, 50
7. Head indistinct, not brown; body only slightly curved, smooth . . . . . Megastigmus, p. 50

Adults

1. Wings exposed, not concealed by wing covers (flies, moths) 2
1. Wings concealed by wing covers (beetles) 6

2. Wings clear; long, upturned ovipositor . . . Megastigmus, p. 50
2. Wings with scales; no ovipositor 3

3. Large moth, wing expanse over 1" (Dioryctria) 4
3. Smaller moth, wing expanse less than 1" 5

4. Moth golden tan in color . . . . . D. xanthoenebares, p. 51
4. Moth silvery grey . . . . . D. abietella, p. 4, 51

5. Fore-wing with light band near tip . . . . . Gelechia, p. 5, 51
5. Fore-wing with three dark bands . . . . . Laspeyresia, p. 51

KEY
TO THE
INSECTS AFFECTING THE CONES
OF
SUGAR AND PONDEROSA PINE

Adults
(continued)

6. Body metallic green or greenish . . . . . .Chrysophana, p. 43
6. Body dark, brownish or black 7

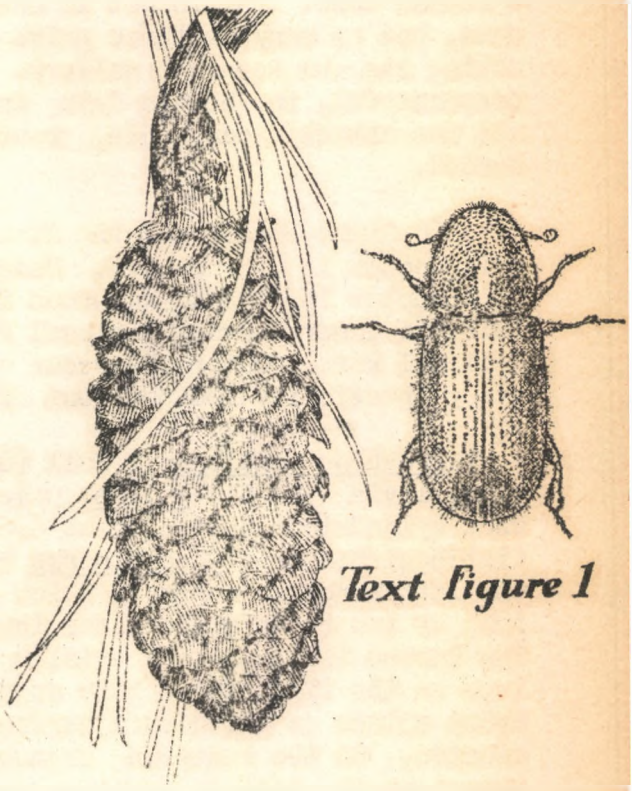
7. Antennae elbowed with club at end (fig. 23) . . . . .Conophthorus, p. 3
7. Antennae straight, not clubbed (fig.22) . . . . . .Ernobius, p. 4,50

SUGAR PINE
(Pinus lambertiana Douglas)

Cone Insects

Coleoptera
(Beetles)

Conophthorus lambertianae Hopk. (Gr., kono, cone + phthoros, destroyer.) the sugar-pine cone beetle*, is a shining, jet black bark beetle ranging from 2.9 to 4.3 mm. (1/6") in length, Text Fig. 1. It can be distinguished from any other beetle found in the cones by the elbowed antennae, (fig. 22). The larvae are almost indistinguishable in color, size and shape, from those of other bark beetle larvae. They are apt, however, to be confused with the larvae of a species of Ernobius that is found in the same type of cones. These latter are hairy, the legs are present on the thoracic segments.



Text figure 1

Emergence takes place during the latter part of May and most of June by the beetles that winter over in the adult stage in the cones on the ground. The attack, Text Fig. 1, is made on the stem of one year old cones only, usually about an inch from the base of the cone and causes a flow of resin that forms a typical pitch tube. The attacking beetle first partially girdles the stem of the green cone which later causes it to break at this point; she next bores into the center and then proceeds up through the axis laying her eggs along the sides of the gallery. The eggs hatch in about two to four days and by the middle of August, when most of the infested or aborted cones have fallen to the ground, the larvae have mostly reached the new adult stage. A few, however, winter over in the larval and pupal stages. From one to thirty-six beetles have been found to develop in one cone. No more than a single generation a year has been recorded.

As the adult beetles are in flight from May through June, the period of most rapid growth of the cones, those cones attacked the latter part of June are much larger than those attacked early in May, the range in length being from two and one half to eight inches. Best development of the brood occurs in cones four to six inches long. Brood does not develop in cones smaller or larger than this. In the smaller infested cones the parent beetle may bore out of the end of the cone and leave, but it is not known whether she attacks

* Miller, J. M. Cone beetles: injury to sugar pine and western yellow pine. U.S.D.A. Bul. 243. 12 p., 5 pl.

a second cone. The insect is monogamous, one pair as a rule inhabit a cone, but as many as three pairs have been found in some cones each pair making its own separate gallery. In occasional instances the attack is unsuccessful, the beetle dying in the pitch, but whether successful or not, all the attacked cones die, growth ceasing very soon after they are infested.

In Giant Forest and the Atwell Mill area of Sequoia National Park, this beetle is very common. Under one tree 139 blighted cones were counted November 13, 1934. Numerous infested cones were observed March 15, 1934, in General Grant National Park. It is also abundant in Yosemite National Park. Outbreaks occur at times in other regions which often destroy practically 100 per cent of the cone crop.

Ernobius pallitarsis Fall (Gr., probably from ernos, young shoot + bius, living in; L., pellos, pale + tarsus, foot.) is a dark brown, somewhat cylindrical beetle about 4.5 mm. (1/5") long. It can easily be distinguished from Conophthorus by its filiform or thread-like antennae, the last three segments of which are subsequal and each of which is as long or longer than the total length of the preceding segments, Fig. 22. The larvae (fig. 49) are whitish with brown heads, hairy, bear distinct legs on the first three body segments, and a band of distinct but minute brown spines on the dorsal surface of body segments two to eight inclusive. On the remaining segments the spines are sparse and indistinct except on the last apparent segment where there is a patch of about twenty-four spines on each side.

The adults of this beetle lay their eggs in the cones that have fallen on the ground as a result of the activities of Conophthorus. The larvae on hatching feed in the stems and scales of the decaying cones until the following spring. Some at least pupate in the cones and emerge during the spring and summer. In Sequoia National Park, larvae, pupae, and adults were found in cones October 10, 1934 in Redwood Canyon, and during November, larvae only in cones, in the region of Atwell Mill and Giant Forest.

The species is also reported breeding in the smaller dead twigs and branches of this tree.

Lepidoptera
(Moths)

Dioryctria abietella D. & S. (Gr., diorysso, to burrow; L., abies, fir.) belongs to a family of insects (Pyralidae - Gr., pyralis, burns.) commonly known as the snout moths. This species, which has a wing expanse of about 35 mm. (1 2/5"), is silvery grey in color with dark wavy bands across the forewings. The larvae are very active, twisting and

turning when disturbed, ivory in color, with brown heads. The body is about 1" long when full grown and covered with long coarse hairs which are over five times as long as the diameter of the spiracles.

The cones and twigs of most species of conifers in the Parks are attacked; but sugar pine is attacked generally less than the other species. Though the attack, which occurs on second year cones only, causes them to grow in a twisted manner, the seeds mature on the uninjured sides. Generally large masses of pitch and frass are found sticking to the surface of the cones over the food burrows. Pupation occurs in cocoons within the cone or in the ground, both in the fall and in the spring. There is a single generation a year for the majority, although some individuals will not emerge until two or even three years after the main brood emergence. The seasonal history, given here is, for the most part, that of the seasonal history of the insect in fir, as there is little information available for it in sugar pine.

Gelechia periculella Busck is a small reddish caterpillar found mining in the cones of this tree. See "ponderosa pine", p. 51.

KEY
TO THE
INSECTS AFFECTING
THE
REPRODUCTION, TWIGS OR FOLIAGE
OF
SUGAR AND PONDEROSA PINE

Larvae and Adults

1. Form scale-like, small, flattened, many hundreds grouped on needles (text fig. 8, 8A). 2
1. Not as above 3

2. Scales white . . . . . Chionaspis, p. 13,55
2. Scales greyish . . . . . Aspidiotus, p. 13,56

3. Fully winged insects, as beetles, moths, or wasps 4
3. Body caterpillar or grub-like (larvae). 5

4. Wings clothed with scales, body with long fine hairs (moths and butterflies).. . . . . Section I, p. 6
4. Wings without scales or wings concealed by wing covers . . . . . .Section II, p. 8

5. Body caterpillar-like, prolegs on abdomen (fig. 1) 6
5. Body usually grub-like, no prolegs on abdomen 7

6. Larvae with prolegs on 2nd abdominal segment (fig. 2) True sawflies, ... p. 13,60
6. Larvae with no prolegs on 2nd abdominal segment (fig. 1) (moths and butterflies) . . . . . .Section I, p. 7

7. Larvae caterpillar-like, feeding on needles. . . . Itycorsia, p. 60
7. Larvae usually grub-like, not feeding on needles. 8

8. Thorax without legs, head indistinct, not brown, body oval, length not over 1/3" . . . . . Parasites, p. VI,S-V
8. Thorax with or without legs, head usually distinct (beetle larvae) . . . . . Section III, p. 9

SECTION I
Moths and Butterflies

Adults

1. Small moths, wing expanse not over 25 mm. (1"). 2
1. Larger, over 25 mm. wing expanse 5

2. Greyish or mottled with black . . . . . .Recurvaria, p. 13,57
2. Moths not as above. 3

KEY
TO THE
INSECTS AFFECTING
THE
REPRODUCTION, TWIGS, OR FOLIAGE
OF
SUGAR AND PONDEROSA PINE

SECTION I
Moths and Butterflies

Adults - Continued

3. Grey moths with tan patch at end of fore-wing . . .Rhyacionia, p. 57
3. Tan, golden, or yellowish moths 4

4. Tan or golden moths . . . . . Tortrix, p. 13
4. Pale yellowish moths . . . . . Zelleria, p. 59

5. Yellowish butterfly with black borders to wings . . Neophasia, p. 57
5. Moths, color not as above 6

6. Large moth, over 3" wing expanse; grey-brown in color, with pinkish cast to hind wings . . . . . .Coloradia, p. 58
6. Smaller moth, grey or tan (Dioryctria) 7

7. Golden tan moth . . . . . D. xanthoenobares, p. 51
7. Silvery grey moth . . . . . D. abietella, p. 4, 51

Larvae

1. Larvae boring in needles . . . . . Recurvaria, p. 13, 57
1. Larvae of other habits 2

2. Larvae boring in twigs and buds . . . . . .Rhyacionia, p. 57
2. Larvae of other habits 3

3. Larvae not confined in feeding, color green or dark brown 4
3. Larvae feeding on foliage of twigs and/or cones, or buds and . . . catkins 6

4. Larvae green or greenish, no spines . . . . . Neophasia, p. 13,57
4. Larvae brownish, spiny . . . . . .Coloradia, p. 58

5. Larvae feeding in colony within web . . . . . Tortrix, p. 13
5. Larvae usually single, ivory colored (Dioryctria) 6

6. Hairs on larvae at least 5 times as long as diameter of spiracles . . . . . .D. abietella, p. 4,51
6. Hairs on larvae usually less than twice as long as diameter of spiracles . . . . . .D. xanthoenobares, p. 51

KEY
TO THE
INSECTS AFFECTING
THE
REPRODUCTION, TWIGS, OR FOLIAGE
OF
SUGAR AND PONDEROSA PINE

SECTION II
Beetles, Sawflies and others

Adults

1. Hind wings concealed by wing covers (beetles) 2
1. Hind wings not concealed by wing covers 15

2. Beetles cylindrical, pronotum scabrous, last three joints of antennae enlarged, but each joint distinct (fig. 25) . . . . . .Stephanopachys, p. 12
2. Beetles not as above 3

3. Antennae not elbowed (fig. 22, 24, 25) 4
3. Antennae elbowed, club-shaped (fig. 23) 6

4. Beetles greyish brown, not over 5 mm. (1/5") in length . . . . . .Ernobius, p. 54
4. Beetles blue or dark purplish; well over 5 mm. in length . . . 5

5. Pronotum hairy, sides rounded (text fig. 7) . . . . Callidium, p. 12,54
5. Pronotum hairless, sides nearly straight (text fig. 2) . . . . . Melanophila, p. 53

6. Head produced into a snout (fig. 36) 7
6. Head not produced into a snout (fig. 37, 38, 39) 10

7. Beetles not over 4 mm. (1/6") long . . . . . Cylindrocopturus, p. 11,52
7. Beetles more than 4 mm. long 8

8. Body mottled reddish brown and white . . . . . Pissodes, p. 11,52
8. Body green to black in color 9

9. Body uniform shiny green to nearly black . . . . . Mordalis, p. 12,52
9. Body dull greyish green, brownish green, or mottled black . . . . . .Scythropus, p. 12,53

10. Beetles small, not over 3 mm. (1/8") long 11
10. Beetles robust over 3 mm. long 12

11. Body brown, shining usually slender . . . . . .Pityophthorus, p. 12
11. Body greyish-black, opaque, stout . . . . . .Carphoborus, p. 12

12. Pronotum constricted towards front, anterior edge emarginate; no tooth on declivity of wing covers (pl. 1, B-F) . . . . . Dendroctonus, p. 12,53
12. Pronotum not usually constricted towards front, (pl. 1, A) 13

KEY
TO THE
INSECTS AFFECTING
THE
REPRODUCTION, TWIGS, OR FOLIAGE
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SUGAR AND PONDEROSA PINE

SECTION II
Beetles, Sawflies and others

Adults - Continued

13. Teeth missing from declivity of wing covers, . . . Hylastes, p. 12
13. Teeth present on declivity of wing covers 14

14. Declivity of wing covers with 3 or more teeth as shown in Figs. 26-33. . . . . Ips, p. 12,53
14. Declivity of wing covers with teeth not as as above, Fig. 34 . . . . . Pityogenes, p. 63

15. Small insects not over 5 mm. (1/5") with long legs, and wings held roof-like at sides of body; mouth parts united for sucking (Aphis) . . . . . Dilachnus, p. 56
15. Usually larger insects; mouth parts suited for biting or chewing 16

16. Wings with many distinct veins, abdomen not narrowed at union with thorax (Sawflies). . . . . Neodiprion, p. 13,60
16. Veins fewer, abdomen narrowed at base. . . . Parasites, p. VI,S-V

SECTION III

Beetle Larvae

1. Larvae with jointed, though often indistinct, legs (fig. 43, 49). 2
1. Larvae with no legs on thoracic segments (fig. 48, 50) 4

2. Body generally cylindrical, but straight, legs minute; . . . . . Callidium, p. 12,54
2. Body short, curved, cylindrical, legs distinct 3

3. Body hairy and with spines on dorsal surface of abdominal segments . . . . . Ernobius, p. 54
3. Body hairy and without spines on dorsal surface of abdominal segments . . . . . Stephanopachys, p. 12

4. Body long, slender, white, resembles horseshoe nail in shape (flatheads, text fig. 2, 5) 5
4. Body short, cylindrical, curved, hairs sparse 6

KEY
TO THE
INSECTS AFFECTING
THE
REPRODUCTION, TWIGS, OR FOLIAGE
OF
SUGAR AND PONDEROSA PINE

SECTION III
Beetles, Sawflies and others

Beetle Larvae - Continued

5. Dorsal plate oblong, ventral plate narrow (fig. 11) Melanophila, p.53
5. Dorsal plate circular, ventral plate circular (fig. 16) 54
. . . . . Chrysobothris, p.54

6. Head with black eyespot on each side. . . Cylindroconturus, p.11,52
6. Head without eyespots 7

7. Front (fig. 54) narrow, much wider than high, pigmentation within this area brown to black, pigmentation outside of front almost entirely lacking . . . . . .Magdalis, p.12,52
7. Front about as high as wide, head more or less uniform brown from mandibles to top of head (fig. 51) 8

8. Larvae small, never over 2.5 mm. (3/25") long, and associated with egg gallery rarely over 1 mm. (1/25") wide
. . . . . Pityophthorus, Carphoborus , p.12
8. Larvae robust, only when quite young less than 2.5 mm. 9

9. Front with transverse swelling (fig. 51). . . . . Dendroctonus, p.12,53
9. Front without transverse swelling (fig. 52) . . . . . .Ips, p.12,53

SUGAR PINE

Insects Affecting Reproduction, Twigs, or Foliage

Coleoptera
Curculionidae
(Weevils)

Cylindrocopturus longulus (Lec.) (Gr., kylindros, cylinder + koptos, chopped small + oura, tail; L., longus, long.) is a small (2.5 to 3.5 mm. long, 1/8") scaly, greyish-black weevil with a narrow, nearly transverse band of white scales near the caudal end of the wing covers. The scales on these beetles are quite characteristic and remind one of the overlapping feathers of a bird. It attacks weakened and perhaps healthy reproduction as well as larger trees. The full grown larva is about 5 mm. (1/5") long, ivory colored with the head nearly the same tone as the body, except for a brownish black irregular area on each side of the head above the mandibles. This marking will serve to distinguish the species from any similarly appearing larva, such as that of Pityogenes, Ips, or Pityophthorus, all of which lack these spots. The pupae are about 4 mm. (1/6") long.

Little is known about the seasonal history and habits of the weevil. Specimens of reproduction infested with larvae of this species were collected in Ackerson Valley, Yosemite National Park, March 1, 1934 by Glen Head, a spotter. The larvae had pupated and adults were emerging in the laboratory in Berkeley, by the second week in April.

The eggs are laid in numbers probably under the bark of the selected trees. At time of pupation distinct pits are made in the wood in the manner of Pissodes yosemite, but they are not packed with shreds. The work of the larvae can be distinguished from that of barkbeetles by the absence of egg galleries and entrance holes.

Pissodes yosemite Hopk. (Gr., pissodes, pitch-like) the Yosemite pine weevil is a reddish brown beetle, ranging from 5 to 8 mm. (1/4") in length. A patch of whitish scales crosses the wing covers at the top of the declivity. The full grown larvae range from 6 to 8 mm. (1/4") in length and closely resemble the larvae of the mountain pine beetle, except that the head is much darker brown and that the upper part of the front of P. yosemite, lacks the ridge and is smooth and shining. These characters can be seen without difficulty by the use of a hand lens.

The adults lay their eggs in the spring of the year, in dying and dead trees and stumps, as well as in apparently healthy reproduction. The eggs are laid in groups under the bark in pits chewed out by the female. Though by fall many larvae have pupated and transformed to adults, some remain in the larval stage until spring. In material collected at Oriole Lake, Sequoia National Park, the latter part of November 1934, adults were still in their pupal chambers, so that probably no emergence occurs until May or June.

SUGAR PINE

Insects Affecting Reproduction, Twigs or Foliage

Coleoptera
Curculionidae
(Weevils) - Continued

The larvae make long winding galleries between the wood and the bark, in the manner of barkbeetles, but the work can be distinguished by the absence of egg galleries, the crookedness of the larval galleries, which radiate from the point where the batch of eggs was laid, and by the cradle-like pupal pits in the wood that are tightly packed with excelsior-like shavings.

Magdalis lecontei Leconte's blue weevil, is frequently found in the adult stage on the needles, chewing out large pits that occasionally cause the needles to wither and fall. It has not been recorded living in the twigs. See "ponderosa pine", p. 52.

Scythropus spp., the green broad nosed weevils, feeds in a manner somewhat similar to the above species. See "ponderosa pine", p. 53.

Scolytidae
(Bark beetles)

Dendroctonus monticolae (p. 30) and Ips confusus (p. 35) at times kill trees as small as 6" D.B.H. but the broods developing in trees of this size are very few. Numerous small trees were killed by these insects during the season of 1934 in the Atwell Mill area of Sequoia National Park. Melanophila gentilis Lec. is also frequently a serious enemy of small trees, see "sugar pine", p. 38. Hylastes gracilis Lec., a small blackish beetle, has been collected in broken limbs. See p. 34. Carphoborus simplex Lec. is frequently found in small dying trees. See p. 33.

Three species of minute bark beetles, Pityophthorus confertus Sw., P. confinus Lec., and P. tuberculatus Eich. are reported infesting sugar pine, but little is known of their seasonal history and habits. The beetles are polygamous and the galleries of a "family" form a star-shaped pattern in the bark. The largest of three species, P. confinus Lec., ranges between 2.3 and 3.0 mm. (1/12"); P. confertus Lec., ranges between 1.9 and 2.8 mm. (1/12"); P. tuberculatus Eich., ranges from 1.7 to 2.1 mm. (1/25"). Some species of this genus attack and kill the twigs of healthy trees.

Callidium antennatum Newm. has been reared from small branches, see, p. 46.

Stephanopachys sp. has been found on the foliage of small branches but it is probable it does not work in them. See p. 47.

SUGAR PINE

Insects Affecting Reproduction, Twigs, or Foliage

Coccidae
(Scale Insects)

Chionaspis pinifoliae (Fitch) the pine leaf scale. See "ponderosa pine", p. 55.

Aspidiotus pini has been observed on trees at Mehrten Creek, Sequoia National Park. See "ponderosa pine", p. 56.

Lepidoptera
(Moths)

The Needle Miners

Recurvaria sp. was first observed by A. Wagner of the Bureau of Entomology at Colony Mill, Sequoia National Park, June 14, 1918, causing a fading of foliage similar to the fading caused by bark beetles. The insects were then in the larval and pupal stage and adults began to emerge by July 10. While doing control work in Sequoia National Park the fall of 1934, Orrin Hamlin found the same type of fading in the tops of large trees up River Valley which was caused by what is probably the same species.

The caterpillars collected were probably about three-fourths grown and were about 7 mm. (7/25") in length, pale green, with black heads. The moths are greyish brown mottled with black patches and are about 5 mm. (1/5") long.

The mines are similar to those of the lodgepole pine needle miner, R. milleri Busck, but the needles of a single fascicle are frequently webbed together, giving the general appearance of the work of a needle tyer.

The Leaf Rollers

Tortrix lambertianae Busck, the sugar pine tortrix, according to Keen, Bul. 7, is occasionally injurious to the new buds killing as much as 90 per cent of the new growth. The caterpillars feed in colonies within a web on the terminal shoots. The adults, which emerge during July, are speckled, tan to golden moths with a wing expanse of 22 mm. (22/25").

The Sulfurs and Whites

Neophasia menapia Felder see "ponderosa pine", p. 57.

Hymenoptera

Tenthredinidae
(Sawflies)

Neodiprion edwardsii (Norton) (Gr., neo, new + di, two + prionotes, made like a saw) is a sawfly belonging to the family Diprionidae. The

females are chunky, pale yellowish, wasp-like insects about 7 mm. (7/25") long. A short, dark, longitudinal marking is present on the dorsal surface of the thorax, just behind the head. The males are darker and the antennae comb-like; the antennae of the females are thread-like. No positively determined larvae are at hand from which a description can be drawn, but larvae that are probably this species are greenish, with shiny black heads and average about 18 mm. (3/4") in length. They look a great deal like hairless caterpillars but can be at once distinguished by the presence of legs on the fifth body segment. Only a rare group of leaf mining caterpillars have legs on this segment.

Larvae collected in Yosemite National Park, June 21, 1913, by Mr. J. M. Miller were found to spin cocoons and pupae by July 7, 1913. None of the pupae transformed. Material collected the following year in other regions were in the pupal stage by July 17th, and began to emerge by September 22, 1914. Pupation generally occurs within brown, parchment like cocoons, about 9 mm. (3/8") long and 13.5 mm. (13/25") wide; that are spun in the duff and needles below the infested tree. Though oviposition has not been observed it probably occurs in the needles during the fall of the year. Damage is done by the larvae stripping each needle until only a narrow shaft is left that soon withers. The larvae usually feed in groups of two or three to a needle.

It is interesting to note that the adults of some, if not many sawflies are predacious. They have been observed feeding on such insects as lady-bird beetles.

Control is easily secured by spraying the needles with lead arsenate; 3 pounds to 100 gallons of water, with 4 ounces of blood albumin spreader.

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

Larvae and Adults

1. Fully developed (winged) insects; as beetles, moths, wasps, and flies 2
1. Body not mature and/or wings absent 8

2. Forewings modified as hardened covers for hind legs (beetles) . . . . . Section II, p. 20
2. Forewings not so modified 3

3. Insects with one pair of wings (Diptera - flies) . . . . . p. V, L-R
3. Insects with two pairs of well developed wings 4

4. Wings with scales, body covered with dense fine hairs (moths and butterflies). . . . . .Vespamima, p. 49,79
4. Wings clear, body without hairs 5

5. Large, robust insects, body over 2/5", and female with long, stiff ovipositor; body metallic blue or dull black; wings yellow or smoky (horntails) . . . . . .Sirex, p. 49,77
5. Insects not as above 6

6. First segment behind head long and slim, dark brown, shiny . . . . . Raphidia, p. V, K
6. First segment behind head not as above 7

7. Large insect over 1/5" long, with broad wings. . . . Termites , p. 80
7. Smaller insects not over 1/5" long, or if over 1/5" long abdomen strongly compressed(Hymenoptera - parasitic wasps) Section III, p. 29

8. Fore-legs modified into pincers, as a crab . Pseudoscorpion, p. VIII,W
8. Fore-legs not so modified 9

9. Body brown or white, antennae long . . . . . Termites, p. 80
9. Body usually white, antennae short, (beetle, caterpillar, and fly larvae) . . . . . Section I, p. 15

SECTION I

Larvae

1. Abdomen with prolegs (fig. 1) . . . . . .Vespamima, p. 49,79
1. Abdomen without prolegs (fig. 48, 49) 2

2. Jointed legs present on thorax, though often minute(fig.43,49) 26
2. Jointed legs abs nt from thorax (fig. 48) 3

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

SECTION I
Larvae - Continued

3. Jaws opposed, distinct, though often somewhat withdrawn into head.4
3. Jaws absent or usually entirely withdrawn into head ("Parasitic" wasps and flies) 19

4. Body cylindrical, U-or S-shaped, head like a flattened ball and directed downward (weevil, bark beetle, and horntail larvae, fig. 48) 5
4. Body cylindrical, flattened, elongated; head directed forward (Flat- and round-headed borers, text fig. 2, 5, 6) 10

5. Body small, curved, no sharply pointed median spine on end of abdomen, head usually dark brown in color; found between wood and bark 6
5. Body elongate, sharply pointed spine on end of abdomen, head very light brown, nearly white in color; boring in solid wood-Sirex, p.49,77

6. Head with a blackish "eye-spot" on each side . . . . . .Cylindrocepturus, p.47,76
6. Head without eye-spots 7

7. Brownish toothed plate on top of body segments 11 and 12 (fig. 50) . . . . . Dendroctonus valens, p.32,62
7. No plate on top of segments 11 and 12 (fig. 48) 8

8. Front roughened and with distinct transverse swelling (fig. 51) . . . . . Dendroctonus monticolae, p.30,62
8. Front without a distinct transverse swelling, but sometimes roughened (fig. 52, 53) 9

9. Front roughened, about as wide as long (fig. 52) Ips confusus, p.35,64
9. Front smooth and shining, appreciably wider than long (fig. 53) . . . . . .Pissodes, p.47,76

10. Second apparent (really first) segment behind head greatly enlarged and usually with ridges or point-like roughenings (text fig. 2, 5, the flat-heads*) 11
10. Second apparent (really first) segment behind head, not appreciably enlarged, and no ridges or point-like roughenings (text fig. 6, the roundheads**) 17

* Burke, H. E. Flat-headed borers affecting forest trees in the United States. U. S. Dept. of Agr., Bul. No. 437., 8 p., 9 pl., 1917.
** Craighead, F. C. North American cerambycid larvae. Dom. Canada Dept. Agr. Bul. No. 27 - New Series. 150 p., 44 pl., 1923.

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

SECTION I
Larvae- Continued

11. Roughenings in ridges, (text fig. 5) very large larva in dead or dying trees . . . . . Chalcophora, p. 44,71
11. Roughenings point-like, r absent (fig. 11-17) 12

12. R ughenings absent (fig. 12, 13, 17) 13
12. Roughenings present (fig. 11, 14, 15, 16) 14

13. D rsal plate marked by a single median groove; ventral plate with a single median groove (fig. 17) . . . . . Chrysophana, p. 43,71
13. Dorsal plate marked by an inverted V; ventral plate with a single median groove 13A

13A Ventral plate bisected by median line (fig. 12) . . .Dicerca, p. 70
13A Ventral plate not bisected by median line (fig. 13) Anthaxia, p. 43,71

14. Dorsal plate of second body segment marked by an inverted Y or U, ventral plate marked by a single line which does not bisect anterior margin (fig. 14) . . . . . Buprestis, p. 41,70
14. Dorsal plate of second body segment marked by an inverted V, ventral plate marked by a single line which bisects it or bisects about two thirds of it (fig. 11, 15, 16) 15

15. Ventral plate narrow, completely bisected at caudal edge (fig. 11, 15)(Melanophila) 16
15. Ventral plate circular only two thirds bisected (fig. 16) . . . . . Chrysobothris, p. 42,70

16. Groove dividing ventral plate extending to anterior margin, roughenings of dorsal plate unevenly spaced, labrum broad, usually emarginate (fig. 15). . . . Melanophila gentilis, p. 38,67
16. Groove dividing ventral plate not extending to anterior margin, roughenings of dorsal plate rather evenly spaced, labrum narrow, usually evenly rounded (fig. 11)(ponderosa pine only) . . . . . Melanophila californica, p. 66

17. Head slightly deflexed; antennal ring not bisected by frontal suture; top of abdominal segments 1-7 with "blistered area" (fig. 3) . . . . . .Monochamus, p. 45,71
17. Head distinctly deflexed; antennal ring bisected by frontal suture; top of abdominal segments 1-7 usually with brownish area but smooth (fig. 4, Acanthocinus) 18

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

SECTION I
Larvae - Continued

18. Last joint of maxillary palpus as long as second; first joint of labial palpus not twice as long as last . . . . . .Acanthocinus obliquus , p.40,69
18. Last joint of maxillary palpus much shorter than second; first joint of labial palpus twice as long as last . . . . . .Acanthocinus spectabilis, p.40,68

19. Body extremely long and slender, white and thread-like, much more than 15 times as long as wide; Scenopinidae, Pseuda- . . . . . .trichia sp., p. V,N
19. Body, if slender and cylindrical not more than 15 times as long as wide; or body oval, rarely over 7 mm. long 20

20. Body oval, not more than 3 times as long as wide, or if more than three times as long as wide, body depressed and covered with heavy bristles 21
20. Body cylindrical, about as wide at middle as near tail-end.22

21. Body depressed, covered with numerous heavy bristles . . . . . Stratiomyiidae, p.VI,Q
21. Body not covered with numerous heavy bristles - . . . . . Parasitic wasps as Coeloides, Pachyceras, p.VI,S-V

22. Head almost jet black, sharply pointed. . . .Xylophagus, p.VI,R
22. Head not jet black, usually blunt 23

23. Body tapered rapidly towards head end . . . . . Lonchaea, p.V,M
23. Body rather blunt towards head end. 24

24. Mouth-parts indistinct, body slender and seldom over 4 mm. long, usually pink in color, though sometimes yellowish white . . . . . .Cecidomyidae, p.V,O
24. Mouth-parts black, distinct 25

25. Top of head and first thoracic segment with brown area . . . . . Medetera, p.V,L
25. Top of head and first thoracic segment without brownish area . . . . . .Asilidae (robber flies), p.V,P

26. Larvae U-shaped, cylindrical, usually densely hairy, and not over 7 mm. long 27
26. Larvae not U-shaped, if cylindrical usually over 7 mm. in length 28

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

SECTION I
Larvae - Continued

27. Larvae with spines on dorsal surface of abdominal segments . . (fig. 49). . . . . .Ernobius, p.4,54
27. Larvae without spines on dorsal surface of abdominal seg- . . . . . Stephanopachys, p.47,76

28. Larvae roughly cylindrical, ivory white, incapable of. . . rapid locomotion when not in burrow; no process on end of abdomen; mature larvae usually over 1" long (roundheads). .29
28. Larvae flattened, usually not ivory colored, a process. . . usually present on end of abdomen; capable of rapid locomotion; mature larvae usually less than 1" long (fig. 43). 34

29. Dorsal margins of epicranial halves of head separated behind. . front (fig. 10) 30
29. Dorsal margin of epicranial halves party fused behind front. . . (fig. 9) 31

30. Form cylindrical, larvae boring in dead stumps and roots . . . . . .Ulochaetes, p.47,73
30. Form flattened, larvae living entirely between wood and bark of dying and recently dead trees . . . . . Stenocorus (Rhagium) . . . . . , p.40,69

31. Epistoma projecting over clypeus, front projecting over epistoma (fig. 18) 32
31. Epistoma not projecting over clypeus, front not projecting over epistoma 33

32. Eyes scarcely visible; four tubercles over epistoma (fig. 18) . . . . . .Ergates, p.47,71
32. Eyes prominent, 3 to 4 in number; (tubercles not as above) . . . . . Tragosoma, p.47,72

33. Roughening of pronotum coarse, spines on end of abdomen acutely conical, nearly touching each other (ponderosa pine only). . . . . .Criocephalus, p.72
33. Roughening of pronotum finer . . . . . .Asemum, p.47,73

Callidium

34. Body brown, hard, head nearly jet black, a pair of terminal hooks present (fig. 8) . . . . . .Alaus, p.IV,G
34. Body usually not brown and hardened, and if so, head not jet black 35

35. No pair of terminal processes on end of abdomen 36
35. A pair of terminal processes on end of abdomen (fig. 43) 38

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

SECTION I
Larvae - Continued

36. Body brown. . . . . .Corticeus, p. II,B
36. Body whitish or purplish. 37

37. Body whitish, head darker, larvae usually small, very active . . . . . Rove- and histerid beetle larvae,
37. Body purplish, head and first thoracic segment very dark brown; body narrowest between 1st and 2nd thoracic segments (Snake-lion larvae) . . . . . .Raphidia, p. V,K

38. Body brown or brownish 39
38. Body not brown 41

39. Base of head distinctly wider than first thoracic segment, sides of body almost parallel; body extremely flattened . .Cucujus, p. II,C
39. Base of head not distinctly wider than first thoracic segment. . 40

40. Larvae with a pair of terminal, upturned processes. . . . . .Aulonium, p.III,E
40. Larvae with a pair of terminal processes projecting. . . straight behind . . . . . Othnius, p.III,D

41. Thoracic segments 2 and 3 each with a pair of light brown areas; body generally pinkish. . . . . .Enoclerus, p. IV,H
41. Thoracic segment 3 with a pair of dark brown areas; body usually greyish (fig. 43) . . . . . Temnochila, p. III,D

SECTION II
Adult Beetles

1. Antennae elbowed and ending in a club (fig. 23) 2
1. Antennae not elbowed and usually not ending in a club (if elbowed, beetles not cylindrical: histerids)(fig. 22, 24, 25) 34

2. Head produced into a long snout (fig. 36) Weevils 3
2. Head not produced into a long snout (fig. 37-39) Bark beetles9

3. Body not over 1/5" long, mottled black and grey or brown 4
3. Body over 1/5" long, black, greenish-black, or mottled white and russet 5

KEY
TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
SUGAR AND PONDEROSA PINE

SECTION II
Adult Beetles - Continued

4. Body slender, wing covers at widest part not much wider than the thorax, no white spot near end of wing covers . . . . . Cylindroceptunus, p.47,76
4. Body robust, wing covers at widest part distinctly wider than thorax; usually a single white spot near end of wing covers . . . . . Gelus, p.76

5. Body greenish to greenish-black, or mottled white and russet. . . 6
5. Body brownish black to jet black 7

6. Body smooth; shining green to greenish black. . Magdalis, p.12,52
6. Body with scales; mottled white and russet. . . Pissodes, p.47,76

7. Body form cylindrical; snout shorter, broad, at nearly right angles to body; antennal club small. . . . . .Rhyncolus, p.75
7. Body form flattened; snout longer, at about 45 degree angle to body, antennal club pronounced (fig. 36)(Cossonus). 8

8. Thorax at widest part as wide as wing covers, C. crenatus, p.75
8. Thorax at widest part narrower than wing covers . . . . . .C. ponderosae, p.75

9. Head not clearly visible from above (fig. 38, 39) 10
9. Head visible from above (fig. 37, 42) 24

10. Declivity of wing covers with teeth or knobs (fig. 26-35). .11
10. Declivity without teeth, though rarely with minute sometimes pointed knobs 20

11. Declivity with pair of large teeth at top and/or no broad horizontal margin at bottom (fig. 34) 12
11. Declivity with 3 to 6 teeth on each side and broad horizontal margin at bottom (fig. 26-33)(Ips) 14

12. Body very hairy, wing covers strongly pitted, declivity with three teeth on each side, second tooth largest, pointed . . . . . Orthotomicus, p.64
12. Body somewhat hairy, wing covers weakly pitted; declivity with two very large teeth at top (males, in part) or three small ones (females, in part) 13

13. Pronotum evenly rounded in front, declivity steep . . . . Pityogenes carinulatus, p.63
13. Pronotum narrowed in front, declivity not steep-P. fossifrons, p.64

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SECTION II
Adult Beetles - Continued

14. Declivity nearly vertical with 3 teeth on each side. . . (fig. 33). . . . . Ips latidens, p.36,65
14. Declivity not vertical, usually 4 to 6 teeth on each side (fig. 26-28, 30-32). 15

15. Third tooth compressed, emarginate; body length not less than 1/4"(fig. 26) . . . . . I. emarginatus, p.36,65
15. Third tooth not emarginate (fig. 27-32) 16

16. Six teeth on declivity (fig. 27)(I. ponderosae. Not yet found in California regions).
16. Four or five teeth on declivity (fig. 28, 30-32). 17

17. Four teeth on declivity (fig. 30, 32). 18
17. Five teeth on declivity (fig. 28, 31) 19

18. Antennae with sutures bisinuate (fig. 32A). .I. oregoni, p.36,64
18. Antennae with sutures angulate (fig. 30A). . I. integer, p.64

19. Body densely clothed with long hairs, especially on declivity; surface coarsely sculptured, antennal suture rounded at middle (fig. 28, 28A) collected so far only in P. monticolae . . . . . .I. vancouveri,
19. Body rather sparsely clothed with long hairs, antennal suture angulate at middle (fig. 25, 31) . . . . . I. confusus, p.35,64

20. Beetles boring between wood and bark, usually in twigs or pith of twigs . . . . . Pityophthorus, p.65
20. Beetles boring pin holes into solid wood 21

21. Robust, darker beetle; eyes on each side divided near middle (fig. 38) . . . . . Trypodendron, p.63
21. Slender, brown beetles; eyes on each side not divided 22

22. Small beetle less than 1/8" long, no fine raised margin near base of pronotum . . . . . Xyloborus, p.63
22. Larger, slender beetle, usually more than 1/8" long, fine raised margin near base of pronotum 23

23. Front of head with numerous, converging, minute grooves (fig.41) . . . . . .Gnathotrichus sulcatus, p.37,65
23. Front of head punctuate with few coarse grooves (fig. 40). . . . . .G. retusus, p.37,65

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TO THE
INSECTS AFFECTING THE TRUNK OR BRANCHES
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SUGAR AND PONDEROSA PINE

SECTION II
Adult Beetles - Continued

24. Basal margin of wing covers raised, toothed, or knobbed. .25
24. Basal margin of wing covers not raised 30

25. Basal raised margin of wing covers extending straight across, scarcely interrupted by scutellum; small species not over 1/12" long (Carphoborus) 26
25. Basal raised margin interruped; large species over 3/25" long (Dendroctonus) 28

26. Prominent longitudinal ridge on declivity, wing covers with numerous greyish erect scales. . . . . .C. ponderosae, p.62
26. Prominent longitudinal ridge on declivity lacking; scales small, usually indistinct 27

27. Antennae with sutures nearly straight across. . .C. radiatae, p.63
27. Antennae with sutures rather strongly curved . . .C. simplex, p.33,62

28. Large beetle over 1/4" long, robust, reddish (pl. 1, F) . . . . . D. valens, p.32,62
28. Smaller beetle seldom over 1/4" long, slender, black when mature 29

29. Pronotum not abruptly narrowed towards front, body not over 1/5" long (pl. 1, B) . . . . . .D. brevicomis, p.61
29. Pronotum abruptly narrowed in front, usually over 1/5" long (pl. 1, C) . . . . . D. monticolae, p.30,62

30. Pronotum widest in front of the middle, third fore-tarsal segment scarcely widened at distal end (fig. 44,46). . . . 31
30. Pronotum widest behind middle, third fore-tarsal segment bi-lobed (fig. 45, 47). 32

31. Larger, not less than 1/5" (5.6 mm.) long, jet black . . . . . Hylastes macer, p.35,65
31. Smaller, not more than 1/6" (4.5) long, black to brownish . . . . . .Hylastes gracilis, p.34,65

32. Pronotum not strongly constricted towards anterior. . . . margin; black with declivity usually mud-colored from . . presence of many scale-like hairs. . .Hylurgops porcsus, p.34,65
32. Pronotum strongly constricted towards anterior margin; . . reddish-brown to very dark brown, never black 33

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SECTION II
Adult Beetles - Continued

33. Wing covers densely covered with scales; surface dull; smaller species not over 1/5" long . . . . . Hylurgops subcostulatus, p.34,65
33. Wing covers with scales chiefly on declivity; surface shiny, larger species generally over 1/5" long; reddish brown . . . . . Hylurgops rugipennis, p.34,65

34. Wing covers strongly abbreviated, so that greater part of dorsal surface of abdomen is exposed 35
34. Wing covers covering most of abdomen 36

35. Wings capable of being folded under wing covers; small beetles . . . . . Staphylinidae (Rove-beetles), p.II,A
35. Wings incapable of being folded under wing-covers-Ulochactes, p.73

36. Tarsal segments 5-5-4 (i.e., fore- and mid-tarsi each with 5 segments, hind-tarsi with 4 segments) 37
36. Tarsal segments 5-5-5, 4-4-4, or some combination other. . than 5-5-4, or if 5-5-4, antennae knobbed or elbowed . . . (cerambycids, buprestids, etc.) 40

37. Pronotum reddish-brown, wing covers much darker brown . Bius, p.II,B
37. Pronotum and wing covers of the same color 38

38. Body shiny, not covered with recumbent hairs . Corticeus, p.II,B
38. Body dull or slightly shining, covered with recumbent hairs 39

39. Pronotum narrower than wing covers; body rather cylindrical . . . . . Ernobius, p.4,54
39. Pronotum about as wide as wing covers, body flattened somewhat . . . . . .Rushia, p.48

40. Compact flattened beetles with prosternum produced into a posterior median process (fig. 5, 6) flat heads and click beetles 41
40. Beetles usually less flattened; prosternum not produced into a posterior median process (fig. 7) cerambycids, clerids, etc. 55

41. Pronotum depressed at union with wing covers (click beetles) . . . . . .Alaus, p.IV,G
41. Pronotum not depressed at union with wing covers (flat heads) . 42

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INSECTS AFFECTING THE TRUNK OR BRANCHES
OF
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SECTION II
Adult Beetles - Continued

42. Body green or blue-green, wing covers slightly ridged; body not over 1/2" long . . . . . Chrysophana, p.43,71
42. Body not above color or if so, more than 1/2" long 43

43. Prosternum sharply pointed behind coxae (fig. 5) Chrysobotris . . 47
43. Prosternum obtusely pointed behind coxae (fig. 6) 44

44. Wing covers almost smooth; anterior tibiae with tooth near tip (fig. 20) . . . . . .Chrysobotris contigua, p.42,70
44. Wing covers with distinct ridges; anterior tibiae dilated at tip (fig. 21) 45

45. Center of pronotum not grooved. . . . . .Chrysobotris dolata, p.43,70
45. Center of pronotum with groove 46

46. End joints of antennae dull red or yellowish . . . . . Chrysobotris dentipes, p.42,70
46. Antennae uniform in color . . Chrysobotris carinipennis, p.42,70

47. Beetles large, over 24 mm. (1") . . . . . .Chalcophora, p.44,71
47. Beetles less than 24 mm. 48

48. Wing covers smooth, not marked with distinct longitudinal ridges (text fig. 2) 49
48. Wing covers marked with numerous, distinct longitudinal ridges (text fig. 3, 10) 54

49. Pronotum truncate at base (fig. 19) . . . . . Anthaxia, p.43,71
49. Pronotum sinuate at base (text fig. 2) Melanophila 50

50. Body greenish blue, no orange markings on wing covers . . . . . .Melanophila gentilis, p.38,67
50. Body bronzy, bronzy-black, or black 51

51. Body bronzy, no orange-brown markings on wing covers . . . . . Melanophila intrusa, p.39,66
51. Body bronzy-black, 0 to 6 orange-brown markings on wing covers . 52

52. Body black, no spots on wing covers; 10 to 14.8 mm (1/2") long . . . . . .Melanophila acuminata, p.66
52. Body bronzy-black, wing covers usually marked with 2 to 12 orange-brown spots 53

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SECTION II
Adult Beetles - Continued

53. Each wing cover with not more than 3 spots; smaller beetle not over 10.5 mm. (2/5") . . . . . .Melanophila californica, p.66
53. Each wing cover with usually 6 spots; a larger beetle over 9.8 mm. . . . . Melanophila consputa, p.66

54. Wing covers not constricted into a distinct tail, (text fig. 3) . . . . . Buprestis, p.41,70
54. Wing covers constricted at end into a distinct tail (text fig. 10) pronotum without punctures along median line . . . . . Dicerca, p.70

55. Body shiny black; antennae distinctly elbowed, wing covers . . shortened, exposing top of last two abdominal segments . . . . . Histeridae, p.IV,F
55. Body not shiny black; antennae not elbowed 56

56. Antennae usually short, terminal segments enlarged 57
56. Antennae slender or serrate, long, tapering towards end; tarsi each with 4 segments (Cerambycidae, text fig. 6, 7, 9, 11, 12) 72

57. Antennae with last three segments consolidated into a knob (fig. 24) . . . . . .Rhizophagus, p.IV,J
57. Antennae with last three segments sometimes enlarged but not consolidated (fig. 25) 58

58. Body cylindrical, roughening on front of pronotum somewhat like Ips . . . . . .Stephanopachys, p.47,76
58. Body flattened somewhat, pronotum not as above 59

59. Pronotum with two ridges starting at anterior margin and parallel with the lateral margin, not quite one half length of pronotum . . . . . Aulonium, p.III,E
59. Pronotum not as above, usually without ridges 60

60. Pronotum convex with fine ridge extending down its full length close to each lateral margin, small beetle not over 3 mm. long . . . . . Laemophloeus, p.II,C
60. Pronotum concave without such fine ridges or much larger beetle 61

61. Body uniform shiny green-blue, robust beetle, about (3/5") long . . . . . .Temnochila, p.III,O
61. Body not as above 62

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INSECTS AFFECTING THE TRUNK OR BRANCHES
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SECTION II
Adult Beetles - Continued

62. Body exceptionally flattened, red, about 3/5" long. . . . . Cucujus, p.II,C
62. Body not as above 63

63. Thorax, legs, and parts of wing covers densely covered with long hairs 64
63. Thorax, legs, and wing covers without, or sparsely covered with hairs 65

64. Abdomen red . . . . . .Enoclerus sphegeus, p.IV,H
64. Abdomen black. . . . . Enoclerus lecontei, p.IV,H

65. Body broadly oval, flattened, wing covers flanged at sides, evenly ridged, without large punctures between ridges; color red-brown . . . . . Ostoma, p.III,D
65. Body not broadly oval, wing covers not as above 66

66. Head, pronotum, and wing covers light yellow to darker brown; wing covers with recumbent hairs . . . . .Epurea, p.IV,J
66. Head, pronotum, and wing covers dark reddish-brown to nearly black; wing covers without short recumbent hairs . .67

67. Eyes prominent, projecting beyond sides of pronotum; average length of body about 1/5" . . . . . .Othnius, p.IV,I
67. Eyes not prominent; length about 2/5" 68

68. Wing covers smooth without prominent ridges, pronotum . . . convex 69
68. Wing covers distinctly ridged, pronotum with narrow longitudinal groove or oval hollow, or body very slender 71

69. Larger beetle, length over 7/25", pronotum distinctly widest at anterior margin . . . . . .Tenebroides, p.III,D
69. Smaller beetle, length not over 7/25", pronotum widest near or behind the middle 70

70. Pronotum oval, sides serrate; beetle not over 1/8" . . . . . .Corticaria, p.IV,J
70. Pronotum with sides nearly parallel, smooth; larger beetle, slender, not less than 1/16" long . . . . Corticotomus, p.III,D

71. Large, nearly black beetle, 1/2" long; pronotum with deep longitudinal groove . . . . . Deretaphrus, p.III,E
71. Small brownish beetles not over 7/25" long 71A

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Adult Beetles - Continued

71A Pronotum concave; beetle not over 1/5" long . . . Lasconotus, p.III,E
71A Pronotum convex; beetle over 1/5" long . . . . . .Airora, p.III,D

72. Pronotum with distinct ridge and one or more spines along each side; large, robust, brown beetles over 1" long . . . 73
72. Pronotum without distinct ridge along each side and generally without spines 74

73. Numerous small spines along each side of pronotum (male), female also with much larger spine at each corner (text fig. 11) . . . . . .Ergates, p.47,71
73. Single coarse spine on each side of pronotum behind the middle . . . . . .Tragosoma, p.47,72

74. Antennae longer than body 75
74. Antennae much shorter than body 78

75. Body brownish, or black mottled with white, no projection at end of abdomen (text fig. 6) Monochamus 76
75. Body greyish with or without dark bands and projection at end of abdomen (text fig. 9) (Acanthocinus) 77

76. Body brown; end of wing cover evenly rounded.M. obtusus, p.45,71
76. Body usually blackish; end of wing cover emarginate . . . . . M. maculosus, p.45,71

77. Smaller, more slender beetle, not over 3/5" long.A. obliquus, p.40,69
77. Larger, more robust beetle, over 3/5" long. . A. spectabilis, p.40,68

78. Body greyish, wing covers distinctly ribbed. Stenocorus, p.40,69
78. Body greenish-blue, brown or black; wing covers weakly or not at all ribbed 79

79. Body greenish-blue, slightly flattened (text fig. 7)Callidium, p.46,71
79. Body brownish or jet black; not appreciably flattened 80

80. Body black; mandibles prominent, head deflexed (text fig. 13) . . . . . .Spondylis, p.74
80. Body brownish, often very dark brown, nearly black 81

81. Pronotum with 2 large shallow pits . . . . . .Criocephalus, p.72
81. Pronotum without 2 large shallow pits (text fig. 12). Asemum, p.72,47

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SECTION III
Hymenoptera

Parasitic Wasps
(Pteromalidae, Eurytomidae, Braconidae, Cynipidae)

1. Abdomen very strongly compressed, large insect over 1/5" long . . . . . .Ibalia, p.VII,V
1. Abdomen not compressed, or slightly so 2

2. Wings with numerous veins . . . . . Braconidae, p.VI,S
2. Only a single heavy vein at anterior margin of fore-wings . .3

3. Body black; surface of pronotum very rough . . . . .Eurytoma, p.VI,U
3. Body green or greenish (Pteromalidae) 4

4. Ovipositor projecting appreciably beyond end of abdomen . . . . . Pachyceras, p.VI,T
4. Ovipositor not projecting appreciably beyond end of abdomen .5

5. Fore-wings with dusky spot . . . . . .Ropalicus, p.VI,T
5. Fore-wings clear . . . . . .Cecidostiba, p.VI,T

SUGAR PINE

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles)

Dendroctonus monticolae Hopk. (Gr., dendron, tree + ktonos, murder; L., mons, mountain + colous, inhabiting.), the mountain pine beetle, is the most important enemy of sugar pines over 10" D.B.H., attacking recently injured, felled and healthy green trees. They do not attack down trees more than nine months old. The adults, Plate 1, C, are shiny black beetles ranging in length from 4.2 to 6.6 mm. (1/5"). The full grown larvae range in size from about 5 to 7 mm. (1/4") and have the general appearance of other Dendroctonus larvae, Fig. 48. They can be distinguished from similarly appearing larvae by the characters given in the key.

Generally, there are two complete generations a year, and frequently a partial third. As attacks commence the first warm days in April and continue through to September, there is considerable overlapping in the development of the broods even in the same tree. Often only the top or lower portion of the tree will be attacked and not until three or four weeks later will the remainder be filled in. In some cases, only the top will be killed and either owing to the resistance of the tree, or more probably to some unknown factor, no more of the tree will be attacked.

The place of entrance is marked by the presence of a pitch tube composed of boring dust and pitch. The larger, stickier, and pitchier the pitch tubes, the greater are the indications that the attack on the tree will be unsuccessful. Pitch tubes that have "pitched out" the attacking beetles are at first white, but turn golden with age. When the beetles attack in numbers sufficient to kill a tree the pitch tubes are composed more of sawdust than pitch; are reddish in color, and often so small that they can be covered with the head of a pencil. In spotting, trees with pitch tubes like this are easily missed; in fact only a well trained and experienced spotter would notice such a tree, but it is such trees as these that have the heaviest broods.

The number of attacks per square foot of infested area averages about nine. They occur more or less evenly entirely around the trunk from about two feet above the ground to a six inch top diameter, and in the larger limbs. The attack generally starts near the top of the tree and works down. The tree may be killed in a few weeks or it may take a succession of generations over a period of several years to complete the destruction. A few beetles can not kill a tree, though rarely they may kill one side. Generally, as soon as a few attacks occur on a tree some attracting odor seems to be given off by the tree that draws beetles from considerable distances. Just what draws the beetles, is not known, it may be derived from the fermentation of the cambium. Whatever it is that lures them,

they come in sufficient numbers, usually to fill in the trunk from top to bottom, generally within ten days from the first attack.

In Yosemite National Park, a sugar pine with a D. B. H. of 9 feet 8 inches had an infested length of about 175 feet, which is about 2450 square feet of infested surface. With an average of 9 attacks per square foot and a pair of beetles to an attack, there were about 44,000 beetles in the tree. Each female lays about 72 eggs per gallery, so that potentially about a million and a half beetles could have emerged from the one tree. This actually never happens, as only a small fraction reach maturity.

There is no possibility of saving a tree after it is attacked. The application of chemicals or washes to green trees as repellents so far has proved a failure. Once the beetles have "decided" to attack a tree only a wire screen around its trunk from top to bottom will prevent infestation by mechanically keeping the beetles away from the bole.

The female alone makes the attack and the egg gallery which starts with a small crook (half an inch or more in length) either to the right or left and then continues up the tree along the grain, always between the wood and the bark. In this host the galleries wind about a great deal more than in lodgepole pine; and at first glance frequently resemble D. brevicomis galleries. They average somewhat over two and a half feet in length, though often they may be over four feet long. In down trees the galleries usually run with the grain of the wood, either up or down the bole, though often they go across the grain winding about in an apparently aimless manner.

The bore of the egg channel is only slightly larger than the diameter of the beetle, so in order to reverse its position the beetle constructs a short groove about half its length into the bark. The groove, which is always perpendicular to the long axis of the tree, is known as the turning niche. Several may be constructed in one gallery. The beetles may also construct a channel or two, to the surface of the bark. The opening, known as a ventilation hole, leading to this channel, is generally under a bark scale and not quite as circular as a hole made by an emerging beetle, and later is often packed with frass (boring dust).

The eggs are laid from one to four in a group, along each side of the gallery beginning about two inches from the crook, and stopping about five inches or more from the end of the gallery. The average number of eggs per inch of gallery is about three. The incubation period averages around eight days during the summer; the larval period when uninterrupted

by winter lasts about five weeks during which time the larvae molt either four or five times. They mine individual galleries at right angles to the egg channel which overlap the galleries of larvae from other egg channels. It is this girdling effect of the larval mines that kills the tree. The pupal period averages close to ten days, and is passed in a cell generally constructed between the wood and the bark, but occasionally entirely concealed in the bark. Pupae present late in the fall probably transform to new adults during the warm days of winter. After transforming, the new adults chew around under the bark, apparently feeding on the soft inner dead bark for varying periods of time before emerging. The number of adults emerging varies considerably. The average is about 75 to a square foot, but it may range from 1 to 150. Some beetles emerge almost as soon as their body structure becomes hardened, though the beetle may still be light brown in color, especially the wing covers which darken last of all. Other beetles remain under the bark a considerable period even after they are jet black. The emergence holes made by the beetle are circular in shape and range from 1.7 to 2.5 mm. (1/12") in size; and can always be distinguished from entrance holes by: (1) the absence of pitch around the opening. (2) the hole not connecting with an egg channel, and (3) the opening usually being on a bark plate or scale, and not in a crack or crevice.

The beetles are semi-monogamous, i.e. generally there is a pair of beetles to a gallery, the male following behind the female and helping to push out the frass and pitch, but occasionally a male takes to wandering from gallery to gallery. In western white pine in eastern Washington, males and females of this species are found in practically equal numbers in the pupal cells but after emerging it seems that more males than females fall by the wayside, so that only 43 per cent of all galleries contained a pair of beetles. Whether this is the same for the beetle in this region has not been worked out.

The females are not parthenogenic. A small percentage of the females emerge after making their first galleries, and cut a second set in another tree.

Dendroctonus valens Lec. (L., valens, powerful.), the red turpentine beetle, is a common bark beetle attacking this tree. The adult; Pl. 1, F, is reddish brown, cylindrical, with the pronotum strongly constricted in front. The range in size is from 6 to 9 mm. (1/3"). The full grown larvae (fig. 50) are about 9 mm. in length and are provided with a brownish plate with seven spines covering the top of the eleventh and twelfth body segments. There is also a double row of brown spots down each side of the

body beginning with the fourth segment and ending with the eleventh segment. A single spot is present on each side of the first segment. The upper and darker row is the spiracles. Early stage larvae also have these markings but less distinctly.

The adults attack only the basal portion of dying and weakened trees, and the stumps of green trees. As attacks occur from May to September, all stages of brood can be found at almost any time of the year. The female lays her eggs over a period of often two or more months so that the progeny of one beetle varies greatly in age. The eggs are laid in great numbers along the sides of the gallery which are much wider in proportion to the size of the body than the galleries of other bark beetles. On hatching, the larvae feed side by side in a common larval mine that is often ten inches or more wide. About eight weeks are required to reach the pupal stage. The pupal period is not known. Observations indicate that there is a single generation a year, though some may take two years to develop according to G. R. Struble of the U. S. Bureau of Entomology.

Infested trees can be distinguished by the large pitch tubes, often two inches in length, around the base of the tree. When first formed the pitch tubes are brownish red in color, but after several months turn a whitish or yellowish pink and become dry and crumbly, and look like mortar scattered on the ground close to the tree.

When spotting trees infested with the mountain pine beetle, the presence of D. valens in the base is a great help in determining whether or not the trees should be marked. As valens attacks in numbers only weakened trees, half a dozen to a dozen fresh pitch tubes around the tree indicate that the tree has been recently weakened by some agent. A close investigation will probably reveal the presence of D. monticolae attacks higher up which without the evidence of the valens tubes would have been missed by the spotter.

Carphoborus simplex Lec. (Gr., karphos, twig splitter + boros, voracious.) is a greyish black beetle 1.9 to 2.4 mm. (1/12") long, with slightly scaly, roughened wing covers. It can be separated from any other species by the characters given in the key. The larval characters are not known The adults make radiating galleries generally in the spring of the year. Buckhorn of the U. S. Bureau of Entomology has reared a single generation per year of this or closely related species in the same limb for the last four years.

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles) - Continued

Hylurgops subcostulatus (Mann.) (Gr., probably hylourgus, breeding in the woods; L., sub, less + costa, ridge.) is a dark brownish beetle ranging in size from 3.8 to 5.0 mm. (1/6"). In general appearance they resemble a miniature D. valens and are often so coated with a dried mud-like substance that it is difficult to see the markings on the body.

The characters for separation of the larvae from those of other bark beetles have not been studied.

According to Keen, in Bulletin 7, the beetle "excavates a short longitudinal, slightly curved gallery in the inner bark at the base of pines killed by (other) bark beetles; especially where the sap has produced a sour condition. Trees are attacked and eggs laid during May and June. New adults develop and emerge in August and September, and another generation develops under the bark of newly infested trees as larvae and new adults."

As the beetles attack only dying trees control is unnecessary.

Hylurgops rugipennis (Mann.)(L., rugi, red + pennis, wing.) is another common beetle that prefers the same conditions in which to breed as H. subcostulatus. It is reddish brown in color and ranges between 4.1 and 5.9 mm. (1/5") in length. They resemble red Dendroctonus more than any other beetle. The larval characters are not well known. The adults are found attacking dying trees during May and June but little else is known of their habits in this tree.

Hylurgops porosus (Lec.)(L., porosus, perforated.) is a black, Dendroctonus-like beetle, ranging in length from 4.7 to 5.5 mm. (1/5"). The declivity is distinctly scaly. The larval characters are not well known. The beetles are of no economic importance.

Hylastes gracilis Lec. (Gr., hylastes, a wood cutter; L., gracilis, slender.) is a slender, jet-black shiny beetle ranging in size from 3.5 to 4.5 mm. (1/6"). Hylastes can be distinguished from Hylurgops by the shape of the pronotum, Fig. 44, 45, and the lobed, third fore-tarsal segment, Fig. 46, 47. The larval characters are not well known. Adults have been collected in General Grant National Park in April, just commencing their galleries in broken limbs, and have also been collected in flight in April, when snow was still on the ground, in the Mariposa Grove, Yosemite National Park. They have also been collected in flight during October and November. Little else is known of their seasonal history but they are not primary insects.

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles) - Continued

Hylastes macer Lec. (L., macer, lean.) is a longish, jet black beetle ranging in size from 5.6 to 6.5 mm. (1/4"). The larvae are not known. Adults have been reared by G. R. Struble during June from trees killed the previous year by the mountain pine beetle. The number of generations per year is not known.

Ips confusus (Lec.)(Gr., ips, name used by ancients for some "worm" that ate wood; L., confusus, perplexed.), the five-spined ponderosa pine engraver beetle, Pl. 1, A, is one of the most common bark beetles in the ponderosa pine-sugar pine stands. The adults range from 4.5 to 5 mm.(1/5") in length. In color, they vary from brown to black. The full grown larvae average about 5 mm. (1/5") in length and are typical scolytid larvae. They can be distinguished from the larvae of D. monticolae by the evenly roughened surface of the front, Fig. 52, and by the sub-apical tooth of the mandible being distant from the apical tooth. The front of the larvae of D. monticolae has a transverse swelling above the middle; below the swelling the surface of the front is very densely punctured, above the swelling the surface is without punctures but has a few small transverse grooves, Fig. 51. The sub-apical tooth of the mandible is close to the apical tooth.

As the beetles winter over chiefly in the adult stage, attacks begin the first warm days of spring. They continue more or less uninterruptedly until cold weather sets in. Unlike D. monticolae, this species is polygamous from three to vive females excavating individual egg galleries from a central or nuptual chamber, as it is called. A typical attack has three galleries which together resemble an inverted tuning fork in shape and run parallel with the grain. An average gallery is about five inches in length with a range of three to seven inches, though some are occasionally longer. From one to eight eggs are laid per inch; an average is about five or six. Instead of laying eggs in groups of two and three as does D. monticolae, this beetle almost always lays each egg in a separate niche and does not nick the wood in the operation.

The larvae on hatching work out radially from the egg gallery and the mines when completed, are seldom over four inches in length. The period of incubation and larval development has not been worked out completely. Keen, Bulletin 7, reports a developmental period during warm weather, from egg to adult, of 42 to 68 days. Three generations a year seem to be the rule.

The insects are rather aggressive, frequently killing second growth as well as the tops of mature trees. Methods of control are the same as

for D. monticolae, except that peeling should not be employed in the winter months as the beetles are in the adult stage during this time and only a few would be destroyed. Though it has not been tried, sun-curing should be effective, as the bark of the tops and small trees is generally sufficiently thin to admit enough heat from the sun to raise the temperature to over 118 degrees F., the minimum temperature required to kill the bark beetle brood.

Ips oregoni (Eich.), the Oregon pine-engraver beetle, breeds only rarely if at all, in this tree. It would be of considerable interest to secure definite information on this point. A description and discussion of its habits is given under "ponderosa pine", p. 64.

Ips latidens (Lec.), the small western pine-engraver beetle, is the smallest species of this genus in the west, ranging in size from 2.7 to 3.9 mm. (1/8"). It is brown in color. They can easily be distinguished from any other bark beetle of this size by the presence of three teeth, the last the largest, on an almost vertical declivity, Fig. 33. Compare with Fig. 32 of I. oregoni and Fig. 34 of Pityogenes carinulatus. The characters for distinguishing the larvae from other similarly appearing larvae has not been worked out.

As the seasonal history has not been studied, the number of generations and developmental period of the various stages in this tree is not known. The beetle is of minor importance.

Ips emarginatus (Lec.), the large western pine-engraver, is as large as any engraver beetle in the United States. It is a dark brown in color and ranges in size from 6 to 7 mm. (1/4"). The distinguishing characters are the four teeth on the declivity, the third tooth of which is much larger than the others and emarginate at the top. Fig. 26.

Distinguishing characters for the larvae have not been worked out, though in general appearance they do not differ from the other bark beetle grubs.

The adults excavate generally three-branched galleries, often three or four feet in length. According to Keen, attacks occur in May and June, and beetles are in flight again during the fall of the year which would indicate possibly two generations a year.

Gnathotrichus retusus (Lec.)(Gr., gnathos, tooth + trichos, hair; L., retusus, blunt.), the western pine-wood stainer, is an ambrosia beetle,

shining dark brown in color and ranging between 3.2 and 3.9 mm. (1/6") in length. It can be distinguished from the following species by the lack of striations on the head, Fig. 40.

The larvae, including the head capsules, are pearly white in color. As they live deep in the wood, they are rarely seen.

The adults attack weakened trees during most of the season, excavating long, (nine inches or more) branched galleries in a horizontal plane into the solid wood. They never mine between the wood and the bark in the manner of Dendroctonus or Ips.

A great many beetles live together in the galleries branching from a single entrance hole. The female lays her eggs each in a separate niche along the roof and floor of the channel. On hatching, the larvae feed only on the food pellets composed of fungus and provided by the parent beetle as a plug in the opening to the "cradle". The "cradle" is formed by the larva enlarging the egg niche, which is always done with the grain of the wood. The wood chewed in enlarging the cradle is swallowed but not digested, according to Hubbard.

The number of generations per year and seasonal history have not been studied.

Considerable damage is done to the wood from a commercial point of view, by the parent galleries, which appear as shot-holes in the sawed product. Within the Parks however, they may be considered to be beneficial in that they attack and breed only in dying trees and thus help to open them up to dead-wood-destroying fungi.

Gnathotrichus sulcatus (Lec.)(L., sulcatus, grooved.) has also been recorded from sugar pine. It ranges between 3.4 to 3.6 mm. (1/8") in length and can be distinguished from G. retusus by the converging striations on the head, Fig. 40, 41.

The seasonal history is not known.

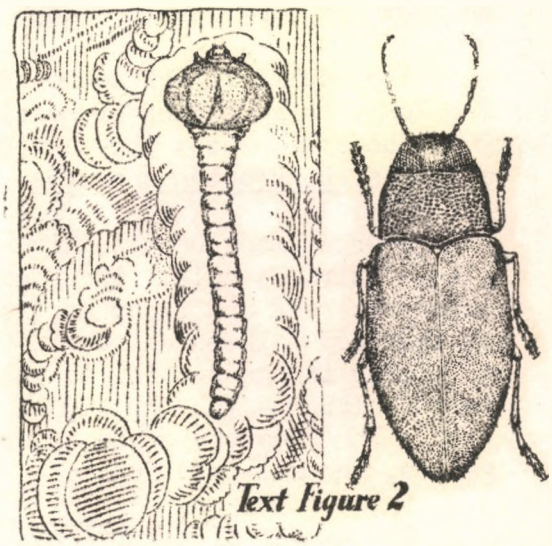
SUGAR PINE

Insect Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed bark borers)

Melanophila gentilis Lec. (Gr., melas, black + phile, loving; L., gentilis, of the same race.) is a beautiful blue-green to purplish beetle, Text Fig. 2, ranging in size from 9 to 12.5 mm. (11/25"). The wing covers are slightly roughened, unpolished, and bear no ridges or punctuations.



Text Figure 2

The larvae are creamy white, legless, and resemble horseshoe nails in shape. When full grown they average about an inch in lenght, and can be distinguished from flat-head larvae of any other genus, or other borers by the characters shown in Fig. 15.

Adults can be found from June to August sunning themselves on, or crawling over a tree looking for a place to lay eggs. Their extreme activity makes them difficult to hold which can best be done by copiously wetting the fingers before sneaking up on them. The eggs, which are laid under bark crevices, are flattish, roughly circular, and light yellow in color. The incubation period is not definitely known. According to Dr. Burke, the period is about two to three weeks. On hatching, the larvae work into the cambium and there make long, very narrow, winding galleries, which can be distinguished by the brownish discoloration of the tissues. As the larvae grow in size the channels become wider and are packed with concentric arc-like bands of chewed material and excrement. Larvae are generally full grown by fall. Pupation occurs in the bark, or between the wood and the bark during April, May, or June. A few pupae have been found as late as the middle of July. The ventral surface of the pupa is turned towards the outside of the tree but the body may be erect, horizontal, or upside down. The larva also seems to burrow with its ventral surface outward.

Observations indicate that there is one generation a year.

Insects Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed bark borers) - Continued

The beetles are frequently quite aggressive, laying eggs in sufficient numbers, that the larvae hatching from them can kill apparently healthy trees. The attacks usually occur in the upper portions of the bole and larger branches, often in conjunction with Ips confusus.

As the beetles do not enter the bark to lay eggs and the larvae force no borings to the outside it is practically impossible to locate infested trees until they have begun to fade. The bark must then be knocked off to locate the larval galleries which, as mentioned above, are at first very fine and difficult to distinguish. Considerable examination is frequently necessary before one can be certain that flat-heads are in the tree.

Burning the tree entirely, or peeling and burning is the best method of control, but sun-curing, if the bark is not too thick and is exposed constantly to direct rays for a sufficient time, should be satisfactory. Flat-head larvae seem to be able to withstand near lethal temperatures for longer periods than bark beetle larvae so that it is necessary to have better exposure during treatment. Temperatures over 125 degrees F., for several hours are lethal to any tree-inhabiting animal life.

Melanophila intrusa Horn has been collected in the larval and pupal stage in March. New adults and one emergence hole were present in the same tree the second week of May. The tree was about eight inches in diameter and had been dead nearly a year. See "ponderosa pine", p. 66, for seasonal history.

SUGAR PINE

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed bark borers)

Acanthocinus spectabilis (Lec.), Text Fig. 9, is rather uncommon in this tree. Because the larvae of the mountain pine beetle feed entirely between the wood and the bark, Acanthocinus probably helps to reduce the brood of this bark beetle by chance consumption and by reducing the available food supply. See "ponderosa pine", p. 68.

Acanthocinus obliquus (Lec.) has been collected on sugar pine in September at Wawona, Yosemite National Park. No other information is available for this insect in this host. See "ponderosa pine", p. 69.

Stenocorus lineatus (Oliv.), the ribbed pine borer, seems to occur but rarely in this tree. See "ponderosa pine", p. 69.

SUGAR PINE

Insects Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed wood borers)

Buprestis aurulenta L. (Gr., bus, cattle + pretho, to swell. Name used by Greeks for an insect that killed stock.) is a beautiful, iridescent blue-green beetle with purplish red borders along the wing-covers. It ranges in length from 16.5 to 20.5 mm. (3/4"). The pronotum of some individuals is often the same color as the borders of the wing covers.

The larvae can be distinguished from other buprestid genera by the characters shown in Fig. 14. When full grown, they average about 25 mm. (1") in length.

The eggs are laid in pitchy wood, around fire scars, and in old wood, never in green tissues. The developmental period of the larvae varies a great deal and requires several years for development. Feeding is done in seemingly bone dry wood, and in wood impregnated with pitch. Adults have emerged from flooring and other woodwork that has been in houses eight or ten years. There are some records of their emerging from wood that has been in buildings even longer than this. Pupation occurs during the summer or fall, the new adults remaining in the pupal cells until the following spring, according to Dr. Burke. Adults are found in flight chiefly during the spring of the year.

Buprestis laeviventris (Lec.) (L., laevis, smooth + venter, belly.) is a dull brownish black beetle, Text Fig. 3, with a greenish to bronzy black pronotum. Each wing cover has three irregularly shaped dull yellow areas that may vary greatly in size and shape. Occasionally all three areas are united into a single band or one of the areas will be broken up into two so that there will be four smaller spots on each wing cover instead of the usual three. The ventral surface of each of the last three abdominal segments generally bears a pair of irregular reddish spots which may occasionally fuse to form a single transverse band. On a few specimens, one may also find red markings on the fourth abdominal segment from the end, or

Text Figure 3

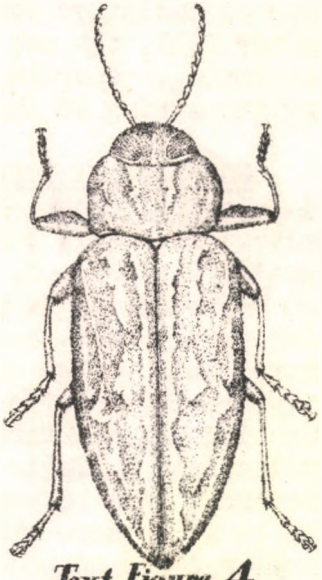
a pair or fused pair of spots on only the last abdominal segment. The front of the male is red. The beetles range in length from 16 to 22 mm. (19/25"). The larvae resemble those of B. aurulenta and are about the same length when full grown.

Eggs are laid chiefly during July and August in recently dead or rotting wood, from which the larvae secure their food. It is probable that it takes several years for the larvae to reach maturity. Pupation occurs in early spring.

Chrysobotris dentipes (Germ.)(Gr., chrysos, gold + bothris, pit; L., dens, tooth + pes, foot.) is a dark bronzy grey, practically black species 13.5 to 22.mm. (22/25") long, Text fig. 4. The wing covers are ridged and somewhat pitted. It closely resembles C. dolata but is more robust and can be distinguished by the characters given in the key, couplet 45, p. 25.

The larvae can be distinguished from the other flat-head genera by the characters given in the key, p. 17.

Adults have been collected by Struble in early July in the pitch on a stump of a felled tree but there are no positive records of it from this tree, though it is recorded as attacking all western pines.



Text Figure 4

Chrysobotris contigua Lec. (L., contigua, beside.), is a rather shiny beetle without distinct ridges or pits on the wing covers. The pronotum is bronzy in color; the wing covers bronzy but with a tinge of blue. The general appearance is somewhat like Melanophila. They range in length from 8 to 10 mm. (3/8"). The seasonal history and habits do not seem to be well known.

Chrysobotris carinipennis Lec. (L., carina, keel of a ship + penna, wing.), is a bronzy black beetle ranging in size from 9.5 to 12 mm.(11/25"). Though reported feeding in this host it seems to breed chiefly in Douglas fir.

Insects Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed wood borers) - Continued

C. dolata Horn., has also been recorded from this tree. It ranges in size from 11 to 13 mm. (1/2") and can be distinguished by the characters given in the key, couplet 45, p. 25.

Anthaxia aencogaster (Lap. & Gor.)(Gr., anthos, flower + axios, worthy of; L., aeneus, copper + Gr., gaster, belly.) is one of the most common and smallest buprestids in the West, ranging in size from 3.8 to 6.9 mm. (1/5").

The larvae can be distinguished from other genera by the characters shown in Fig. 13. When full grown they average 11 mm (11/25") in length.

The adults can be found in flight from early spring to early fall and on many kinds of flowers. They lay their eggs in dead and dying trees and the larvae mine the outer wood and bark.

Chrysophana placida (Lec.)(Gr., chrysos, gold + phanos, show; L., placida, still.), the placid buprestid, is a green to greenish red beetle 8 to 12 mm. (2/5") long. In color, the head and pronotum are a uniform bronze or green and a bronze band usually extends diagonally down each wing cover from the upper outside to the lower inside.

The larvae, when full grown, are about 14 mm. (7/12") in length, and can be separated from other buprestid larvae by the characters given in they key, couplet 11, p. 17.

According to Burke*, the adults are in flight from March to September and lay their eggs in many types of wood such as pine window- and door-casings, normal, dying and dead wood of many different kinds of trees and the cones of ponderosa nd knobcone pine. Apparently only dead or injured sugar pine is attacked.

* Burke, H. E. Notes on some western Buprestidae. Jour. Ec. Ent. 10: 330. 1917.

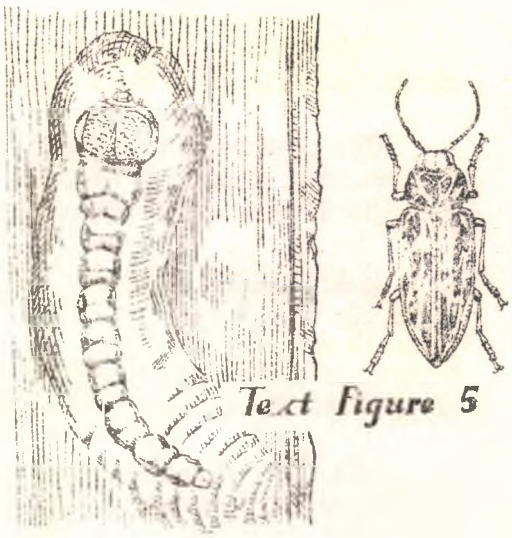
SUGAR PINE

Insects Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed wood borers) - Continued

Chalcophora angulicollis (Lec.)(Gr., chalcos, copper + phoros, carrying; L., angulus, corner + collum, neck.), the sculptured pine buprestid, is a bronzy black beetle, Text Fig. 5, ranging between 24 and 30 mm. (1 1/12") in length. It is the largest flathead in the Sierra region. The larvae when full grown are about 60 mm. (2 2/5") long. They can be distinguished from other flat-head larvae by the characters given in the key, couplet 11, p. 17.



Text Figure 5

The eggs are laid in masses covered with a varnish-like substance (Burke) or more generally in pits chewed out of the bark by the female during June, July, and August, in stumps and branches of recently dead and dying trees. On hatching, the larvae mine into the solid wood and require several years to reach maturity. Adults have been collected in pupal cells the latter part of August, and in other host trees at earlier periods. It is probable that they remain in the tree until the following spring, although in one instance, in ponderosa pine, adults were observed by J. C. Evenden of the U. S. Bureau of Entomology, emerging as late as October 16.

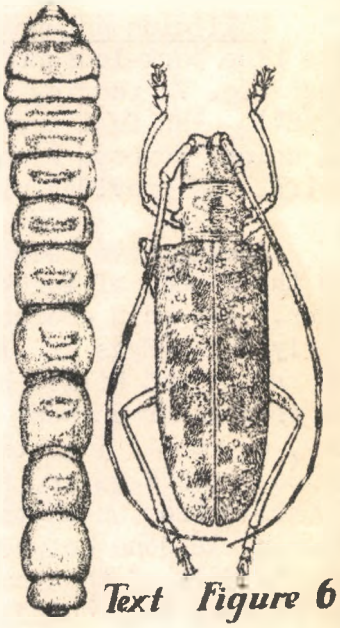
SUGAR PINE

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed wood borers)

Monochamus maculosus Hald. (Gr., monos, one + chamos, fetter; L., maculosus, spotted.), the spotted pine sawyer, Text Fig. 6, is one of the most common large insects around freshly fallen green trees. The adults range in size from 14 to 26.5 mm. (4/5"). In color they vary from brown to nearly black. They can best be distinguished from the other species by the characters given in the key, p. 28.



Text Figure 6

The larvae when full grown are about 40 mm. (1 3/5") in length, roughly circular in cross section, whitish, and legless though very active when removed from the bark. They can be distinguished from the larvae of Acanthocinus which they closely resemble by the less deflexed head and the characters given in the key, couplet 17, p. 17.

The pupae are about 20 mm. in length (4/5") and can be easily distinguished from the pupae of Acanthocinus by the antennae being curled up in a three-fold spiral on the wing pads.

The eggs are laid in groups of from 1 to 6 (Craighead) in holes chewed by the females in the bark of recently fallen trees or in the bark of trees not dead more than a few months. After hatching, the larvae mine through the cambium layer until nearly mature and then mine into the solid wood to a depth of several inches. The mines of the larger larvae are packed solid with coarse frass. Before pupation they excavate a channel almost to the surface of the wood and then back down the channel to pupate. As a rule there is a single generation a year and adults can be found in flight all summer long.

Although some adults of this genus do extensive feeding on the foliage and bark of small branches often killing them, there is no record of this species feeding in this way.

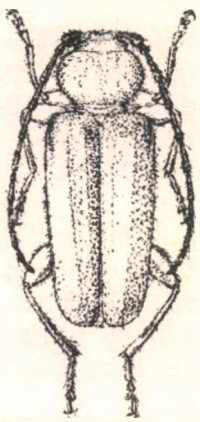
Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed wood borers) - Continued

Monochamus obtusus Casey resembles closely the brown phase of M. maculosus in general appearance and habits, and ranges in size from 13.5 to 20 mm. (17/25"). It is more commonly found on firs than pines. Adults have been collected at Wawona, Yosemite National Park in October on fire scorched sugar pine.

Callidium antennatum Newm., (Gr., kallos, beauty + idea, appear.), the blue bark-loosener, is a beautiful blue-green to blue-black beetle, Text Fig. 7, ranging in size from 9 to 16 mm. (1/2"). The full grown larvae are ivory white in color, covered with long chestnut-colored hairs, and provided with small but distinct legs.



Text Figure 7

Adults have been found in flight as early as the middle of March in General Grant National Park. The main emergence probably occurssduring early May. Eggs are laid under the bark scales of trees just killed by the mountain pine beetle or from other causes, as well as in trees, lumber, or rustic logs that have been considerably dried out. Eggs are frequently laid in the same material from which the adults have just emerged.* Feeding is done between the wood and the bark but in the fall of the year when the larvae are ready to pupate, they burrow vertically into the wood for about two inches, construct a pupal cell, then work back up the gallery and make a channel in the bark almost to its surface. They then return to the pupal cell and plug the gallery end with frass. Pupation takes place generally late in the season. Most of them winter over in the pupal stage but a few remain as larvae or pre-pupal larvae and transform in the spring. After transforming, the new adults chew out the plug at the end of the gallery and escape by pushing off the few bark scales left by the larvae.

Logs to be used for rustic cabins, or where the bark is to be left on should be cut preferably during the fall or winter and treated before

* Miller, J. M. Damage to seasoned yellow pine lumber by a bark loosener, Callidium antennatum Newm. Mimeographed bulletin U. S. Bureau of Entomology, Berkeley, California. 1933.

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed wood borers) - Continued

spring with one part of crude pyridine or coal tar creosote diluted with three parts kerosene.* A mixture of 25 per cent Pine Oil No. 5, 25 per cent Pine Oil No. 15, and 50 per cent Pine Oil No. 6, applied to green logs also seems to be fairly effective in preventing wood borer damage.**

Asemum mokelumne Casey has been reared in June from trees killed the previous summer by the mountain pine beetle. See "ponderosa pine", p. 73.

Ergates spiculatus Lec., see "ponderosa pine", p. 71.

Tragosoma harrisi Lec., see "ponderosa pine", p. 72.

Ulochaetes leoninus Lec., see "ponderosa pine", p. 73.

Curculionidae
(Weevils)

Cylindrocopturus longulus (Lec.) is a small weevil often found on the bark of infested trees but it probably attacks second growth more frequently. See p. 47.

Gelus californicus (Lec.) closely resembles the above species. It has been reared from trees killed the year previous by the mountain pine beetle. It can be distinguished by the characters given in the key, couplet 4, p. 21. There are no records to indicate that it is even destructive to weakened trees. See "ponderosa pine", p. 76.

Pissodes yosemite Hopk., the Yosemite pine weevil, often attacks the butts of weakened or dying trees, as well as reproduction. See p. 76.

Miscellaneous Beetles

Stephanopachys pacificus (Casey)(Gr., stephanos, crest + pachys, thick.) closely resembles a bark beetle but can be easily distinguished as the antennae are not club shaped. The beetles are dark brown to nearly

* St. George, R. A. Protection of log cabins, rustic work and unseasoned wood from injurious insects. U.S.D.A. Farmer's Bul. 1582. 19 p. Illus. 1929.
** Thompson, F. M. Pine oils as agents for protecting rustic furniture and log cabins from various wood borers, Jour. Ec. Ent. 25: 347-351. 1932.

black cylindrical and are 4 to 5.5 mm. (1/5") long.

The larvae are yellowish white, somewhat hairy, the head withdrawn, the mandibles not toothed, no spines present on the dorsal surface of the body, and the spiracles of the abdomen are all practically the same size.

Adults have been collected in flight during June and July, and have been reared in the spring from trees killed by the mountain pine beetle the previous year, but as the beetles mine the bark of green as well as dead trees, little significance can be attached to this record. The insects also work between the wood and the bark of dead trees, often grooving the wood.

Rushia californica Fall is an evenly colored medium to dark brown shiny beetle 4.2 to 8.5 mm. (1/4") long. The pronotum and wing covers have no distinctive ridges or other markings but are sparsely covered with short, recumbent hairs. The larvae are somewhat flattened with a pair of upturned hooks at the end of the abdomen. The beetles are commonly seen running over the bark of infested trees and the larvae feed in the decaying tissues.

SUGAR PINE

Insects Affecting the Trunk or Branches

Hymenoptera

Siricidae
(Horntails or wood wasps)

Sirex areolatus (Cress.), the western horntail is a blue-black wasp-like insect, the female of which is 24 to 35 mm. (1 1/4") long; the male 13 to 25 mm. (3/4") long and the abdominal segments 3 to 7 reddish yellow. The wings are evenly smoky brown. The characters for separation of the larvae from other species are not known.

Little is known of the seasonal history. A male was collected on this host September 9 in Sequoia National Park. See also Sirex californicus, "ponderosa pine", p. 77.

Sirex behrensi (Cress.) is recorded from this host. See "ponderosa pine", p. 78.

Lepidoptera

Aegeriidae
(The Pitch Moths)

Vespamima sequoiae (Hy. Edw.), the Sequoia pitch moth, is found in the pitch around trunks. See "ponderosa pine", p. 79.

PONDEROSA PINE

Cone Insects

Coleoptera
(Beetles)

Conophthorus ponderosae Hopk.* (Gr., cono, cone + phthorus, destroyer.), the western ponderosa-pine cone beetle, is a shiny, stout cylindrical bark beetle 2.8 to 4.1 mm. (1/8") long, and does not differ appreciably in any stage from C. lambertianae in sugar pine, p. 3.

The seasonal history and habits likewise are similar to that of C. lambertianae differing chiefly in the following points: (1) The attacks occur two to three weeks earlier, i.e. during April. (2) The attacks occur in the base of the cone as ponderosa pinescones have no stalk. (3) Before boring into the center of cone to lay her eggs the beetle mines completely around the long axis forming a tunnel with a peculiar twist. (4) The infested cones remain on the trees and the beetles pass the winter in them. (5) The cones attacked vary in length from 1 to 5 inches. (6) The damage is not so extensive to the cones of this tree as to sugar pine.

Ernobius pallitarsis Fall is frequently found in the cones after they have fallen to the ground. They can be distinguished from the above beetle by the characters given in the key, p. 2. For full description and seasonal history see "sugar pine", p. 4.

Hymenoptera
(Wasps)

Megastigmus albifrons Walk., (Gr., megas, large + stigmos, spot; L., albus, white + frons, front.) is a small wasp-like insect about 6 mm. (1/4") long, with an upcurved ovipositor about half as long as the body. The thorax of the male is yellowish, the abdomen is dark brown. The female is uniformly brown. The larvae are chalky white, with distinct black mandibles, and no long or distinct hairs on the body. When full grown they are about 1/5" long.

Emergence occurs chiefly during April and May but sometimes earlier, and often extends into late June. The female bores into the second year cone with her long ovipositor and lays her eggs in the developing seeds. The larvae feed on the seeds until fall, when they are practically full grown. Winter is probably passed in the pupal stage, as pupae have been found the latter part of January. As far as is known there is a single generation a year.

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* Miller, J. M. Cone beetles: injury to sugar and western yellow pine. U.S.D.A. Bulletin 243. 12 p., 5 pl.

PONDEROSA PINE

Cone Insects

Lepidoptera
(Moths)

Dioryctria xanthoenobares Dyar is a beautiful moth with golden tan fore-wings which have a lighter wavy line near the outer margin. The hind legs are creamy white in color. The wing expanse is about 30 mm. (1 1/5"). The larvae when full grown are about 17 mm. (3/5") long, cylindrical, ivory colored with dark brown heads, and the hairs on the body are short, weak, and rarely over twice the diameter of the spiracle . The hooks on the prolegs are of one type and form a broad single-rowed oval.

The adults are in flight during July and August. As far as is known the habits are roughly similar to D. abietella which also feeds in the cones of this tree, see "sugar pine, p. 4. D. xanthoenobares, however, generally pupates in the cones.

Laspeyresia piperana (Kearf.)(Laspeyre, name of a German entomologist) is greyish brown, with three darker bands across the wings, and about 11 mm. (2/5") long. The larvae are about 12 mm. long when full grown, cylindrical, slightly pinkish in color. There are only a few pairs of short-ish hairs on the boyd. The hooks on the prolegs are of one type and form a narrow single-rowed circle.

The adults emerge in the spring and lay their eggs on the surface of the second year cones. On hatching, the larvae mine into the stem and then feed on the developing seeds, often doing considerable damage. Winter is passed in the larval stage. J. M. Miller of the U. S. Bureau of Entomology has collected prepupae and pupae in early April in Yosemite Valley.

Gelechia periculella Busck is a brownish grey moth with a light band near the tip of the fore-wing. It is about 9 mm. (2/5") long. The larvae are reddish, with the hooks on the prolegs made up of two different types.

Feeding is done in the decaying cones. Winter is passed in the larval stage and the adults emerge the first part of June.

PONDEROSA PINE

Insects Affecting Reproduction, Twigs, or Foliage

Coleoptera

Curculionidae
(Weevils)

Cylindrocepturus, see "sugar pine", p. 11.

Pissodes californicus Hopk., is a mottled greyish grown weevil about 6 mm. (1/4") long. It resembles P. yosemite but can be distinguished by the broad, closely punctured pronotum with its emarginate anterior edge, and by the broad, flattened, third and fifth interspaces on the wing covers. The characters for separating the larvae from P. yosemite have not been worked out.

The adults according to Hopkins* attack living trees causing serious scars. The species is described from a single specimen collected on the floor of Yosemite Valley by Dr. Hopkins, June 13, 1904. It is apparently a rare species.

Pissodes yosemite Hopk. was also described from a specimen collected in ponderosa pine near Mirror Lake, Yosemite National Park by Dr. Hopkins, June 13, 1904. It is reported to work in the terminals as well as the bases of trees. It closely resembles the above species. See "sugar pine", p. 11.

Magdalis lecontei Horn (L., magdalis, a cylinder.) is a blue-green weevil 6 to 8 mm. (1/3") long. The larvae are about 6 mm. long and resemble Pissodes larvae in general appearance but can easily be separated by the characters given in the key, couplet 7, p. 10.

Emergence occurs during the spring months, when the adults feed for a time on the needles. Soon eggs are laid in punctures made by the female in the branches and small limbs of recently likked trees, slash, and the like. On hatching, the larvae mine out the bark and wood leaving only a thin layer of bark and a small core of wood between which powdery frass is packed. Winter is passed in the larval stage. There is probably not more than one generation a year.

Magdalis cuneiformis Horn. The larvae have been collected in Sequoia National Park in November, boring in the pith of the terminals and upper branches of pole size reproduction that had been killed during the summer and fall by Ips confusus and the western pine beetle. They resemble Pissodes larvae but can be distinguished from P. yosemite and P. terminalis (which so far has been found only in lodgepole pine) by the

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* Hopkins, A. D. I. Contributions towards a monograph of the bark-weevils of the genus Pissodes. U.S.D.A. Tech. Ser. No. 20, Part I, x, 68 p., 22 pl. 1911.

Insects Affecting Reproduction, Twigs, or Foliage

Coleoptera

Curculionidae
(Weevils) - Continued

broadly oval, slightly hardened surface of the dorsum of the first thoracic segment. This region in the other two species is narrow and in P. yosemite divided by a transverse groove. The head, especially near the mandibles is also much darker brown than that on the other two species, but in other respects resembles the head of a Pissodes rather than the head of a Magdalis larva. Pupation occurs during May. The adults are bluish green with distinct striae on the wing covers, and are about 9 mm. (2/5") long.

Scythropus californicus Horn (Gr., skythropos, dark.) is a copper-grey to grey short-nosed weevil 6 to 8 mm. (1/4") long, with the pronotum usually a bright coppery color. The larvae are not known. The adults are found chiefly during March, April, and May, feeding on the needles by biting out chunks on the side. Winter is passed probably in the adult stage and mating takes place in the spring.

Scythropus albidus Fall is greyish green, mottled with brown and black; 6 to 7 mm. long. Scythropus ferrugineus Csy. is a dull greyish coppery color with sometimes a greenish tinge. It is 6 to 8 mm. long. There are several other species of this genus which also feed on the needles but little is known about the seasonal history of any species as they seldom do sufficient feeding to cause serious damage to the foliage.

Bark beetles and others

Dendroctonus monticolae and Ips confusus occasionally attack trees down to as small as 3" in diameter, see "sugar pine", p. 12. D. brevicomis, see p. 61, occasionally attacks trees down to 5" in diameter and in conjunction with the two previous species is attracted to areas by road and other slash and windfalls, often killing great numbers of trees, without, however, being able to produce heavy broods. Destruction induced by road and other slash, is seldom extensive or of long duration, but because the damage is often along roads where the trees can not well be spared, attention should be given to the proper disposal of the cuttings.

Melanophila gentilis Lec. occasionally attacks reproduction, see "sugar pine", p. 38.

Insects Affecting Reproduction, Twigs, or Foliage

Coleoptera

Bark beetles and others - Continued

Callidium hirtellum Lec., which has been reared from twigs, is a cylindrical cerambycid with yellowish to dark brown wing covers, reddish yellow pronotum, and black head. They are from 6.5 to 9 mm. (1/3") long. The adults emerge in the spring of the year.

Chrysobotris contigua Lec. has been reared from twigs as well as large limbs, see "sugar pine", p. 42.

Ernobius sp. has been reared from twigs infested with Magdalis lecontei, see "sugar pine", p. 4.

PONDEROSA PINE

Insects Affecting Reproduction, Twigs, or Foliage

Homoptera

Coccidae
(Scale insects)

Chionaspis pinifoliae Fitch (Gr., aspis, shield; L., pinifoliae, of pine leaves.), the pine leaf scale*, is one of the most common and widely distributed scale insects, Text Fig. 8. It often occurs in overlapping thousands on the needles of this and many other conifers, giving a white-washed appearance to the foliage. In spite of its numbers it rarely causes the death of even small trees.

Text Figure 8

Text Figure 8A

The full grown female scale is white, roughly pear-shaped, and slightly over 3 mm. (1/8") long and 1 mm. wide. Two light-brown molted "skins" are present at the smaller end of the scale. These are the "skins" of the first two stages. The male scale has but one molted skin and is considerably smaller and proportionately narrower than the female. The white color of the scales is caused by a wax-like secretion that covers the body after the first molt.

Winter is passed chiefly in the egg stage under the female scale. On hatching in the spring, the young insects are quite active, crawling around over the needles for some time before settling down to feed. After the first molt the legs are lost by both sexes; though the female remains in the same spot the rest of her life, the male develops later into a fully winged insect. The number of generations in the sugar pine-ponderosa pine belt does not seem to be known. Considering the elevation it is probable that there is a single brood a year, though on the warmer slopes there may be two broods.

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* Herrick, G. W. Some shade tree pests and their control. Cornell Univ. Agr. Exp. Sta., Bul. 515, 26 p., Illus., Ithaca, N. Y. 1931.

Insects Affecting Reproduction, Twigs, or Foliage

Homoptera

Coccidae
(Scale insects) - Continued

Control

Around camp grounds, control by spraying may be worth while to preserve the appearance of the reproduction and smaller trees. The Doane mixture, which is made up as follows, has been recommended by Herrick.

Volck Oil (light)	1 gallon
Nicotine sulfate	½ pint
Gold dust	7½ pounds
Water	50 gallons

The spray should be applied during the period of two ro three weeks that the young are hatching from the eggs. This will have to be determined by careful observations.

In dry regions, it has been recommended that the trees be watered a day or two before spraying and for two days afterwards. If there are two generations a year, it will be necessary to spray a second time.

Aspidiotus pini Comst. is an oval, blackish-grey scale (Text fig. 8A) with a brownish nipple-like center. When full grown they are about 3 mm. (1/8") long.

The habits are similar to the foregoing species, but the details of the life-history have not been worked out. It can be controlled by the same spray recommended for the above insect.

Aphididae
(Plant lice)

Dilachnus ponderosa (Williams) is a rather large, hairy, brownish aphis with 6 segmented antennae and long hind legs. The immature stages are black, and wingless but otherwise resemble the adult in general appearance.

This species has only been collected on Jeffrey pine in California but it, or a closely related species is found feeding on the twigs of ponderosa pine. The insect produces large quantities of honeydew (which is nearly pure sugar) in which a black-smutting fungus grows. When autos are parked under trees with large colonies of this aphis, they become so thickly spotted with honeydew that it may be necessary at times to institute control measures against the insect to prevent this nuisance. A light miscible oil is an effective remedy.

PONDEROSA PINE

Insects Affecting Reproduction, Twigs, or Foliage

Lepidoptera
(Moths)

Rhyacionia pasadenana (Kearfott) is a pretty greyish moth with the tips of the fore-wings russet. When spread, it ranges from 14 to 21 mm. (4/5") across. The larvae are pinkish and about 12 mm. (1/2") long; the pupae 8 mm. (1/3") long.

The adults transform from overwintering pupae and are in flight during early spring, laying their eggs in the terminals and laterals of reproduction. On hatching the larvae mine out the twig, causing it to die or become deformed. Pupation occurs on the twig at the base of the needles in a pitchy covered cocoon, closely resembling the needle sheath. According to Harry Lange of the U. S. Bureau of Entomology, there is a two year life cycle, the larvae pupating during the spring of the second year.

Recurvaria sp. has been collected in the needles of trees near Atwell Mill, Sequoia National Park. Nothing else is known of its habits.

Neophasia menapia Felder, the pine butterfly*, a close relative of the cabbage butterfly, is an extremely interesting species because of its unusual habit of feeding on pines, and because of the rapidity with which it builds up periodically to amazing numbers. During epidemics it has been reported to be so numerous as to darken the sun, to fall into streams in such numbers to cause damming, and hogs have died from over eating on them. Fortunately, in the Sierras they are not as serious a menace as they are in the Cascades and Idaho.

The wing expanse ranges from about 40 to 60 mm. (2"). The basal color of the wings of the female is whitish yellow with the outer margins black. In addition the apical margin of the hind wings is often tinged with orange. The male is whiter and has less black on the hind wings, which is confined to a narrow and often faint band paralleling the margins a short distance in. The scales on the veins are also occasionally black.

Evenden describes the eggs as being emerald green, 1.5 mm. (1/23") in length, firmly cemented together, and laid along the needle in rows of 5 to 20 at an angle of 45 degrees pointed towards the tip of the needle.

The full grown larva is about 25 mm. (1") long, dark green, and dotted with two lateral stripes down each side. The head is pale green and dotted with white raised tubercles. The head of the first stage larva is shiny black. The pupa is about 13 mm. (1/2") long, and greyish-green in color.

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* Evenden, J. C. The pine butterfly, Neophasia menapia Felder. Illus. Jour. Agr. Res. 33: 339-344. 1926

Insects Affecting Reproduction, Twigs or Foliage

Lepidoptera
(Moths) - Continued

Adults are in flight and lay their eggs the latter part of August. In flight the adults seem to prefer to hover near the tops of tall trees, and rarely come close to the ground. The eggs hatch the following spring about the time the new needles begin to appear. By the end of July, when full growth is reached the larvae begin to drop to the ground (by means of silken threads) in search of stumps, posts or grasses where they pupate.

Coloradia pandora Blake, the pandora moth*, is a large insect ranging in wing spread from 85 to 95 mm. (3½"). The abdomen is blackish and each segment is clothed with a band of fairly long grey hairs. The fore-wings are brownish grey, with a small but distinct black spot near the upper middle. The eggs are about 2.5 mm. (1/8") long, somewhat flask-shaped, dull green, and the micropyle is obtuse. The young larvae are dark brown; the mature larvae yellowish green, and 60 to 70 mm. (2 3/5") long. A double row of coarse spines extends down the back and a double row of smaller spines along each side of the caterpillar. The pupae are 25 to 38 mm. (1 3/8") long, and dark brown in color.

Although Patterson has collected this insect in Yosemite National Park above Yosemite Falls, it is rather uncommon and nothing is known of its habits this far south.

Farther north it is potentially a serious enemy of this tree and P. jeffreyi. It also feeds on lodgepole pine when in association with Jeffrey pine. Adults are in flight during all of July. The principal period of oviposition is from July 10 to 20, the eggs being laid in groups of 3 to 70 or occasionally singly. The incubation period is about 40 days. On hatching, the larvae feed gregariously, and hibernate together among the needles at the ends of the lower branches.

Feeding is continued the following season until the end of June when pupation begins to take place. The larvae crawl to the ground and construct oval cells, a few of which may be sparsely lined with silk, from 1 to 5 inches below the surface of the soil. By July 5, all larvae are in the pupal stage and remain in this stage until the following July. Thus there is a two year life cycle, the principal emergence occuring during the even years around Klamath, Oregon; and odd years in Yosemite National Park and on the adjoining Inyo and Mono National Forests.

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* Patterson, J. E. The pandora moth, a periodic pest of the western pine forests. U.S.D.A. Tech. Bul. 137. 19p., Illus. 1929.

It is a well known fact that one time they were roasted and eaten by the Western Indians*.

Zelleria haimbachi Busck has a white head and uniformly yellowish-white wings with an expanse of about 10 mm. The larvae are not well known. The pupa is about 6 mm. long, dark brown, bears four spines at the end of the abdomen, and the antennae end even with the lower edge of the wing pads.

This species seems to be fairly common in the Sierra. There was no positive record of it in California before 1934**.

Specimens collected probably in the pupal stage in the region of the Lassen National Forest by R. L. Furniss of the Bureau of Entomology, July 25, 1934, emerged between July 30 and August 5 of the same year. Larvae that were probably this species were collected in May 1930 by K. A. Salman of the Bureau of Entomology at the Eddy Tree breeding station, Placerville. These pupated between June 2 and June 4 and one adult emerged before winter, the remainder died. The larvae web the needles together and then feed at their bases until they are cut off completely, but hang from the twig by the webbing. Nothing else is known of its habits in the Sierra region, where it has not yet become a serious pest.

* Essig, E. O. The value of insects to the California Indians. Scientific Month., 38: 181-186. 1934.
** Lange, Jr., W. H. A new locality record for California. Pan-Pacific Entomologist. 11: 82. 1935.

PONDEROSA PINE

Insects Affecting Reproduction, Twigs, or Foliage

Hymenoptera

Tenthridinidae
(Sawflies)

Neodiprion fulviceps (Cress.)(Gr., neos, new + di, two + prion, saw; L., fulvus, brown + ceps, head.), is a waspish-looking insect about 8 mm. (1/3") long. The females are yellowish with thread-like antennae; the males darker with comb-like antennae. The larvae when full grown are about a half inch long, and green with black heads.

Emergence occurs during the last of August, and early September. The eggs are laid in the needles probably soon after the adults emerge. When ready to pupate the larvae spin tan-colored cocoons which are attached to the twigs. J. M. Miller of the U. S. Bureau of Entomology collected full grown larvae, during the latter part of June, which began to spin cocoons as early as July 8.

There have been no serious outbreaks of this insect but it is of a group that often causes serious damage. Control is easily secured by lead arsenate sprays.

Pamphiliidae or Xyelidae

Itycorsia sp., or a closely related genus belongs to a group of insects, the web-spinning or the Xyelid sawflies, about which very little is known. The adults of this species are not known. The larva is yellowish with sometimes a touch of green; the head is yellow-brown with a pair of black eye spots, short but distinct, seven-jointed antennae, and prolegs are lacking. This character serves to distinguish them from the true sawflies (fig. 2).

Larvae were collected in the region of Lassen National Forest by R. L. Furniss of the Bureau of Entomology, July 25, 1934, but none could be reared to the adult stage. They have the peculiar habit, when on the ground, of crawling around on their backs, which they seem to use as well as if they were provided with legs. When feeding, they web the needles to a considerable extent.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles)

Dendroctonus brevicomis Lec. (Gr., dendron, tree + ktonus, murder; L., brevis, short + come, hair.), the western pine beetle, attacks only Coulter and ponderosa pine and is the insect most destructive to the latter tree in California and Oregon, killing several million mature and nearly mature trees every year. The insect is but 3 to 5 mm. (1/5") long, cylindrical, and shiny black, Pl. 1, B. The larvae (fig. 48) are white, with brown heads. The pupae (fig. 48A) are white until transformation.

The beetles are in flight from March to November as there are usually three generations a year (sometimes more depending on the season) and considerable unevenness in the developmental period of the brood of one generation. The attacks are made against apparently healthy trees though they also attack green felled trees, windfalls, and trees of slow growth. In fact when not in great numbers they seem to prever the slower growing trees. A few beetles can not kill a tree; it takes a concentration of several thousand to do so; the average is 10 to 25 parent beetles to the square foot of the main portion of the bole of the tree. As soon as a few beetles begin to bore into the trunk, some sort of odor is apparently given off by the tree, which attracts other beetles for miles; as a result, the tree is soon filled in from top to bottom.

The insects mine out extensive, winding, crisscross, and branched galleries entirely between the wood and the bark, each female laying an average of about 40 eggs. As is the case with the mountain pine beetle, the female after laying a batch of eggs in one tree often chews her way out and lays a second batch of eggs in some other infested tree and even a third batch in a third tree. The eggs are laid in niches along the sides of the gallery, usually about four to the inch and there are about 11 feet of gallery to the square foot, according to the studies of H. L. Person.

On hatching, the larvae mine between the wood and the bark for a distance of about half an inch, or until they have molted once, and then burrow into the bark where they complete their feeding, entirely concealed. If the bark is removed from the tree after the larvae enter it they can still complete development. Pupation occurs (after the fourth molt according to the studies of K. A. Salman of the Bureau of Entomology) in the bark with the heads generally turned towards the center of the tree. This appears to be the reason why when infested bark is removed from a tree the great majority of the beetles emerge from the inner surface. Because of this peculiarity, one can easily check on the effectiveness of a solar heat control project. By the position of these emergence holes, one can determine whether the bark was removed for treatment after the beetles had

emerged; whether the beetles were in the bark when it was removed but not sufficiently exposed to the sun to kill the brood, or whether good control was secured. This is one of the best means for determining the efficiency of treatment by insect control crews.

Control Methods

Control is secured by felling the infested tree and either burning the bark or during the summer, removing the bark and exposing it to the sun's rays. These are sufficiently hot to raise the bark temperature to 110 to 130 degrees F., when the air temperature averages from 80 to 95 degrees.* If the bark temperature reaches 115 to 118 degrees for a period of 2 hours, complete brood mortality is assured, and none survives even a brief exposure to 120 degrees.

The details of control work are admirably given in "Control of the western pine beetle",** and there has also been prepared a small illustrated manual of the methods of bark beetle control, copies of each of which may be secured by writing the Field Division of Forestry, N. P. S. Berkeley, California.

Dendroctonus monticolae Hopk., the mountain pine beetle, is a common enemy of smaller trees. Their galleries in ponderosa pine are generally much longer than their galleries in what seems to be their preferred host, lodgepole pine. See "sugar pine", p. 30, for discussing seasonal history and habits.

Dendroctonus valens Lec., affects this tree in the same manner as sugar pine, see p. 32.

Carphoborus simplex Lec. is a fairly common species in the tops and smaller trees. See "sugar pine", p. 33.

Carphoborus ponderosae Sw. is a dull greyish-black beetle about 2.1 mm. (1/12") long. It can be separated from other species of Carphoborus by the characters given in the key, couplets 26, p. 23. The seasonal history and habits are not well known.

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* Miller, J. M. High and low lethal temperatures for the western pine beetle. Illus. Jl. Agr. Res. 43: 303-321. 1931

** Prepared by the Portland Office of the Division of Forest Insects and the Forest Service, U. S. Dept. Agr.

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles) - Continued

Carphoborus radiatae Sw. resembles the above species but is somewhat smaller, ranging from 1.9 to 2.1 mm. in length; the wing covers are reddish. As with the other species the habits are not well known.

Trypodendron ponderosae Sw. (Gr., trypao, I bore + dendron, tree) is a stout reddish to dark brown ambrosia beetle about 3.5 mm. (1/6") long with the base of the pronotum a lighter brown. It can be distinguished from the other bark beetles by the key characters, couplet 21, p. 22. Neither the larval characters nor the seasonal history are well known.

The adults make winding galleries in the solid wood of weakened trees, laying the eggs in niches on the upper and lower sides. On hatching, the larvae chew out small "cradles" which they enlarge as they grow. Feeding is done entirely on a fungus growth that is provided as plugs in the opening to the "cradle" by either of the parent beetles. Several pairs of beetles unite to form a colony but each pair maintains its own quarters.

As the beetles attack only weakened trees they are seldom of economical importance in the Parks.

Xyleborus scopulorum Hopk., is a slender, shiny, brown to nearly black ambrosia beetle about 2.8 mm. (1/8") long, that bores into solid wood of weakened trees much in the same manner as Trypodendron. It can be distinguished by the key characters, couplet 21, p. 22.

The seasonal history is but poorly known, and the habits given here are those of a closely related species. Eggs are laid loose in the main galleries and the larvae on hatching feed freely in these tunnels.. Pupation occurs likewise in the main gallery. The males are very few in proportion to the number of females and wingless. When conditions dry out so as to become unfavorable for growing fungus gardens, the females leave the tree and take flight to some more suitable host, leaving the few males in a bad way for if the fungus is not sufficiently well cropped it grows so rapidly that it smothers its occupants. When this begins to happen the males collect together forming what is known as a "bachelor chamber" or death-cell, where they are able to survive a short time longer.

Pityogenes carinulatus (Lec.)(Gr., pity, pine + genes, reared; L., carinulatus, ridged.) at first glance resembles a small Ips oregoni. In length it ranges from 2.9 to 3.7 mm. (1/8"). It can be distinguished by the characters given in the key, couplet 11, p. 21, and a comparison of Fig. 33 and 34. The characters for distinguishing the larvae from other bark beetle larvae are not known.

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles) - Continued

The adults are polygamous and excavate star-shaped galleries usually in the larger branches. Often as many as nine galleries may radiate from a single nuptual chamber. There are several generations a year, but the complete seasonal history is not known.

Pityogenes fossifrons (Lec.)(L., fossa, pit + frons, front of head), is a more slender beetle than the above, being about 2.5 mm. (1/10") long. The male lacks the large teeth on the top of the declivity. It is not a common species in this tree in this region, having a more northerly range.

Orthotomicus ornatus Sw. (Gr., orthos, straight + tomichos, skilled in cutting; L., ornatus, ornate.) is a hairy, brown insect 2.3 to 3.2 mm. (1/8") long. The characters for distinguishing the larvae from other bark beetles have not been worked out. The beetles work in the limbs and trunk of trees recently killed by Dendroctonus.

Ips confusus (Lec.) is often destructive to small trees and the tops of mature ones. As the habits and seasonal history are similar in this and sugar pine, they need not be discussed further. See "sugar pine", p. 35.

Ips oregoni (Eich.), the Oregon pine engraver beetle, is often associated with and frequently confused with the I. confusus. Their general appearance and color are practically the same, except that the adults of the former species are somewhat smaller, ranging in size from 3.7 to 4.6 mm. (1/6"). They can be easily distinguished by the four spines on the declivity and the shape of the antennae, Fig. 32, 32A. Full grown larvae average about 4.5 mm. in size.

The adults can be found during the entire season as there may be as many as five generations a year. Winter is passed chiefly in the adult stage under the bark, in stumps, and similar situations, often in great concentrations.

The beetle is polygamous, usually a male and three females being found to an attack. The galleries are generally three-branched and seldom over 5" long.

Ips integer (Eich.) closely resembles the above species but is somewhat larger, being 4.8 to 6.3 mm. (1/4") long, and can be distinguished by the characters given in the key, couplet 18, p. 22, and Fig. 30, 30A. The characters for distinguishing the larvae from the other Ips are not known.

Insects Affecting the Trunk or Branches

Coleoptera

Scolytidae
(Bark beetles) - Continued

The habits are also similar to Ips oregoni. It has been collected at Glacier Point, Yosemite National Park by R. L. Furniss in lodgepole pine which is the preferred host in this region. Though there are no records of it from ponderosa pine in this area, it probably rarely occurs in this tree.

The following list completes the known records of bark beetles that attack ponderosa pine, but as these also attack sugar pine they are discussed under this tree. Hylurgops rugipennis, H. porosus, and H. subcostulatus, p. 34; Ips latidens, and I. emarginatus, p. 36; Gnathotrichus retusus and G. sulcatus, p. 36; Pityophthorus confinus, P. confertus, and P. tuberculatus, p. 12. There are a great many more species of the genus Pityophthorus that attack the twigs and smaller branches, but as they are very difficult to distinguish and little is known about their relative values they are not discussed farther.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed bark borers)

Melanophila californica Van D. (Gr., melanos, black + philes, loving.) is a bronzy black beetle 8.5 to 10.5 mm. (3/5") long, that is often quite destructive to ponderosa pine. Each wing cover is often marked with oval orange brown spots, one to three in number.

The larvae can be distinguished from those of M. gentilis by the key, couplet 16, p. 17. These characters are somewhat variable but by using the combination of characters it appears possible to separate the two.

The adults emerge in early spring chiefly April and May and lay their eggs in apparently healthy as well as dying trees, especially those recently attacked by D. brevicomis though they may precede them. The larvae on hatching mine in the cambium layer only until ready to pupate when they make a cell in the bark or outer wood. Winter is passed apparently in the prepupal stage. Bark from a small tree killed the previous year by these insects was collected by K. A. Salman of the U. S. Bureau of Entomolgoy, at Aspen Valley, Yosemite National Park, early in March 1934. The insects were in the prepupal stage at this time and adults began to emerge about a month later. There is apparently one generation a year. The general habits are similar to M. gentilis, see "sugar pine", p. 38.

Melanophila intrusa Horn is a dark bronzy colored beetle ranging between 6.5 and 10 mm. (1/3") in length. The larvae when full grown are about 12 mm. (1/2") in length.

The adults lay eggs in dying limbs and trees. Larval development probably occupies a year as pupae have been found the middle of May in trees infested the previous year. Pupal cells may occur either in the wood or in the bark. Emergence seems to occur chiefly in early June.

Melanophila acuminata (DeG.) is a black species with no markings on the wing covers, 10 to 14.8 mm. (1/2") long. It attacks dying and injured trees, and is of wide distribution, being found over the entire Northern United States and Canada, and Europe. Pupation occurs during the spring and summer, according to H. E. Burke of the Bureau of Entomology.

Melanophila consputa Lec. is a black species 9.8 to 16 mm. (1/2") long, with 6 orange brown markings on each wing cover. Sometimes these markings are very faint and occasionally several are fused together to form a longitudinal or horizontal band. Adults are in flight from

June to September, and are frequently attracted in great numbers to fires, causing considerable annoyance to those fighting fire by biting the neck and hands. Eggs are laid in dying and dead trees. Pupation occurs during spring and summer.

Melanophila gentilis Lec. is common in down ponderosa pine, see "sugar pine", p. 38, as the habits in the two hosts are similar.

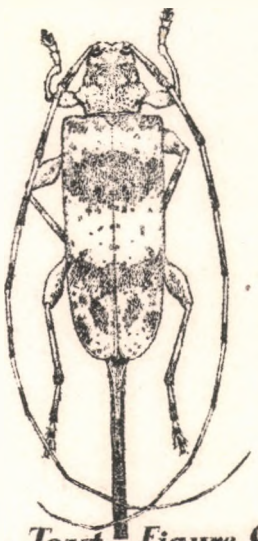
PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed bark borers)

Acanthocinus spectabilis (Lec.)(Gr., acanthos, bear claw; L., spectabilis, remarkable) is a striking, mottled-grey beetle ranging in length (to the tip of wing covers only) from 18 to 22.5 mm.(4/5"), Text Fig. 9. Of ten specimens measured, four were males and all but one of these (which was one millimeter shorter) were appreciably larger than the largest female. This is rather interesting for the reverse is the rule with other beetles. Two, broad, continuous, licorice-black bands cross the wing covers just below the region where the middle and hind pair of legs project beyond the sides of the body. A narrower and generally interrupted band crosses the wing covers near their tip. Two small roughly circular areas of short brown hairs are present near the anterior margin of the pronotum and a more irregular area of the same colored hairs is present to the outside and slightly anterior to each of these areas. The antennae of the males are somewhat more than three times the length of the body; those of the females are slightly more than twice the length of the body.



Text Figure 9

The larvae are ivory white, cylindrical, and taper slightly towards the caudal end. Legs are absent. They resemble very closely the larvae of Monochamus but can be distinguished by the head and first thoracic segment being more strongly deflexed, by the absence of "blistered" areas on abdominal segments 1 to 7, (fig. 4) and by the frontal suture bisecting the antennal ring.

The pupa is about 19 mm. (19/25") in length, and differs most obviously from the pupae of Monochamus by the antennae which extend down to near the end of the abdomen, then curves back along the ventral surface, and terminates near the head.

The adults are in flight from May to September, and lay their eggs under the bark crevices of trees recently attacked by the mountain pine beetle or other decadent or recently dead trees.

Feeding is done entirely between the wood and the bark, and often the young larvae force out from their galleries copious quantities of

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed bark borers) - Continued

coarse brown or white shreds which fall in relatively large heaps below the opening. Full growth is usually attained within a year, pupation occuring chiefly during late May and June in the outer bark of trees in which the eggs were laid the previous season.

In many trees infested with either the western pine beetle or the mountain pine beetle, A. spectabilis larvae are fairly numerous in the lower bole and help destroy the brood of the latter beetles not only by feeding on tissue that would support bark beetle brood, thus starving it out, but also by consuming any brood that happened to be in the path of their indiscriminate feeding. This however, is of no appreciable factor in the natural control of the western pine beetle in this tree. Blackman* reports it in Arizona destroying in this manner large amounts of brood of the Black Hills beetle in ponderosa pine.

Acanthocinus obliquus(Lec.) resembles A. spectabilis in general color and shape, but is considerably smaller, ranging in length from 9 to 13.5 mm. (1/2"). The beetles principally attack the upper portions of the bole of trees infested with Ips confusus and according to R. L. Furniss may be of value in helping to reduce the broods of this beetle.

Adults have been collected on ponderosa pine during June, July, and August. Pupation and transformation to adults in some cases occurs during the fall, the beetles wintering over in the pupal cell. Pupation however seems to occur more generally during May and June.

Stenocorus lineatus (Oliv.)(Gr., stenos, narrow + koros, warrior; L., lineatum, lined.), the ribbed pine borer, is a mottled grey and brown, with black, a large spine at the middle of the sides of the pronotum and ridged wing covers. It ranges in length from 14 to 17 mm. (3/5"). The larvae are flattened, with distinct legs; when full grown about 1" long, and can be distinguished from other larvae by the characters in the key, couplet 29, p.19.

Adults are found in the spring on bark beetle infested trees. The larva works between the wood and the bark, and when ready to pupate constructs an oval cell of excelsior-like frass. Pupation and transformation to the adult stage occurs during the summer and the adults winter over under the bark. There is usually one generation a year but Craighead mentions that development may extend to the second year. The beetle is not common in Yosemite or Sequoia National Parks, being of a more northerly range.

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* Blackman, M. W. The Black Hills Beetle. N. Y. State College of Forestry Bul. 31, Syracuse, N. Y. 1931.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Buprestidae
(Flat-headed wood borers)

Buprestis aurulenta L. see "sugar pine, p. 41.

Buprestis laeviventris (Lec.) see "sugar pine, p. 41.

Dicerca tenebrosa (Kby.)(Gr., di, two + cercus, tail; L., tenebrosus, dark.) is a uniformly dull blackish, flathead with slightly ridged wing covers, marked with small shiny areas, Text Fig. 10. It ranges in length from 16 to 22 mm. (3/4"). The larvae can be distinguished from other flathead genera by the characters given in the key, couplet 12, p. 17.

Text Figure 10

Adults have been collected in flight during July, August and September. The larvae bore into the solid wood of dying and recently dead trees.

Chrysobothris caurina Horn (Gr., chrysos, gold + bothris, pit; L., caurina, ridge.) is a bronzy, grey-black flathead 10 to 14 mm. (1/2") long, with irregular coppery areas on the wing covers. The larvae bore in the dead wood of trunks and limbs.

Chrysobothris californica Lec. is one of the largest beetles of the genus, ranging from 15 to 17 mm. (2/3") in length. The wing covers are coppery with shiny black irregularly spaced raised areas. The larvae mine in the dead trunk and also exposed roots.

Besides the above species and the four listed under sugar pine, p. 42, which also attack this tree there are three other species of Chrysobothris recorded for this host for this region, but which are not especially common. They are C. falli Van D. 10 to 13 mm. (1/2") long; C. monticolae Horn, distinctly greyish and 11 to 15 mm. long; and C. pseudotsugae Van D. 10 to 14 mm. long, which is greyish-black with no distinct coppery areas and is more common in the firs.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed wood borers)

Anthaxia aeneogaster (Lap. and Gor.) see "sugar pine", p. 43.

Chrysophana placida (Lec.) see "sugar pine", p. 43.

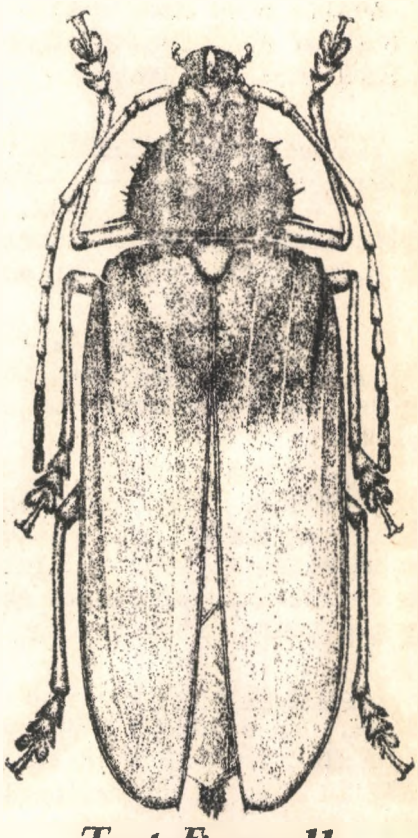
Chalcophora angulicollis (Lec.) see "sugar pine", p. 44.

Monochamus maculosus Hald, the spotted pine sawyer, see "sugar pine", p. 45.

Monochamus obtusus Casey, the obtuse pine sawyer, see "sugar pine", p. 46.

Callidium antennatum Newm., the blue bark-loosener, is a common insect in this host, see "sugar pine", p. 46.

Ergates spiculatus Lec. (Gr., ergates, one who works the soil; L., spiculum, small point.), the ponderosa pine borer, is the largest beetle in the west, ranging in size from 45 to 61 mm. (2"), Text Fig. 11. In color it is a uniform brown, though the pronotum is generally darker than the wing covers. No hairs are apparent on the pronotum. There is an appreciable difference in form between the males and females. The pronotum of the former is dull, impressed with two large triangular pits anterior to the middle; nearly as wide as the base of the wing covers, and the lateral margins very lightly spined. The pronotum of the female is shiny; rather coarsely pitted; considerably narrower than the base of the wing cover, and the lateral margins provided with a large spine at each end.



Text Figure 11

The larvae, when full grown, are about 2½" long, cylindrical, densely wrinkled. The body surface dull, finely and densely roughened; the eyes scarcely visible.

Insects Affecting the Trunk or Branches

Coleoptera

Cerambycidae
(Round-headed wood borers) - Continued

Adults have been collected in Sequoia National Park late in April on trees killed the previous year by the western pine beetle, and in Yosemite National Park on sugar pine during July and August. The larvae are found in decaying as well as pitchy stumps. Several years are probably required for development from egg to adult.

Tragosoma depsarium (L.) var. harrisi Lec. (Gr., trag, goat + soma, body; L., depsarium, kneaded.), the Harris pine borer, resembles Ergates in general appearance, but ranges in length from 22 to 37 mm. (1 1/5"). The pronotum is distinctly hairy, and a distinct spine projects below the middle of the lateral margin. In general appearance the larvae is similar to Ergates but can be distinguished from the latter by the three or four prominent eyes.

Adults have been collected during June and August. Eggs are laid in the bark of dead trees. There is a record of one collected laying eggs the fore part of August.

Criocephalus productus Lec. (Gr., crio, ram + cephalus, head; L., productus, elongated.) is a slender, very dark brown or practically black species 19 to 27 mm. (1") long. The wing covers are smooth with two slight longitudinal ridges, the pronotum has a rather large oval, shallow pit on each side and is smooth or only slightly roughened.

The larvae are white, rather densely covered with fine brown hair, robust, slightly depressed anteriorly, and compressed posteriorly. The roughnesses of the pronotum are coarse and mixed with smooth areas.

Adults can be found on the bases of dead, and dying trees during most of the season. Eggs are laid in the crevices of the bark, and the larvae on hatching burrow between the wood and the bark for a short time and then mine into the sapwood and later the heartwood. The galleries are packed with coarse excelsior-like shavings. Pupation occurs in the sapwood, probably two years after the egg is laid.

Asemum nitidum Lec. (Gr., a, without + sema, markings; L., nitidus, shining.) is a somewhat shiny, very dark brown to almost black beetle, ranging in size from 12 to 21 mm. The larvae when full grown are about 20 mm. (4/5") in length, and slightly depressed. The body surface is sparsely covered with fine, brownish hairs. The pronotum is deeply velured. Legs are present but inconspicuous and two small spines are present on the last abdominal segment.

Insects Affecting the Trunk or Branches

Coleoptera

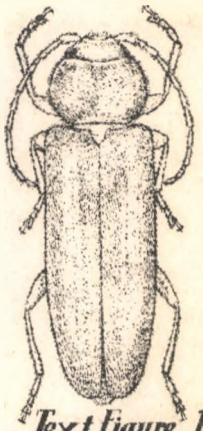
Cerambycidae
(Round-headed wood borers) - Continued

Adults are in flight from May to September. The eggs are laid in bark crevices of trees recently dead and larvae on hatching mine in the cambium layer but a very short time before they work into the sapwood and later into the heartwood, packing their mines closely with granular and shredded frass. Pupation normally occurs in the outer sapwood. The full developmental period does not seem to have been worked out.

Asemum atrum Esch. is a dull, uniformly black beetle ranging in size from 10.5 to 17 mm. (3/5"). The larvae closely resemble the preceding species, and the habits are somewhat similar. Adults have been collected during May, June, and July.

Asemum mokolumne (Csy.) is a shiny, uniformly brown beetle, Text Fig. 12, ranging in size from 10 to 18 mm. (3/5"). The larvae are practically indistinguishable from the previous species.

The main emergence of the adults seems to be from May to July. Eggs are laid in the same manner as the previous species, but in trees of seemingly greater range of decay. Adults have been reared not only from trees dead as long as four years, but also from trees (sugar pine) killed the previous season by bark beetles. The developmental period therefore can be as short as a year. Winter is passed in the larval stage, and pupation takes place in the outer bark.



Text Figure 12

Ulochaetes leoninus Lec. (Gr., oulotrichos, wooly-haired; L., leoninus, lion-like.), the lion beetle, is a threatening-looking though harmless insect, ranging in size from 19 to 29 mm. (1"). The smaller individuals are those reared from fir. The antennae and legs are black except the near end of the tibiae which are yellowish, the head and prothorax densely covered with yellowish hairs; the wing covers are extremely short, covering the abdomen somewhat less than one third its length. The basal portions are black, the apical portions yellow and generally shiny. The general appearance is that of a bumble bee.

The larvae are cylindrical, shining, and sparsely clothed with very fine short whitish hairs; the pronotum is roughened and velvety. When full grown they are about 30 mm. (1 1/5") in length.

Insects Affecting the Trunk or Branches

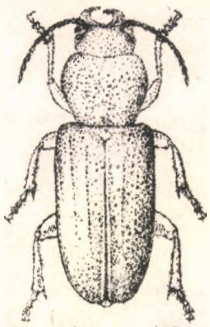
Coleoptera

Cerambycidae
(Round-headed wood borers) - Continued

Adults have been collected from April to August. Eggs are laid near the base of dead trees. The larvae mine into the sapwood and heartwood of the stumps and roots and pack their galleries tightly with finely shredded borings. Pupation occurs during the spring and summer. The period required for development from egg to adult is not known.

Spondylis uniformis Mann. (Gr., spondyle, root inhabiting insect.), Text Fig. 13, is a shiny, uniform black, rather cylindrical beetle 10 to 19 mm. (3/5") long. The larvae have never been seen, or at least described.

The adults are found very early in the spring, often in great numbers, especially around dusk. They are believed to bore into the ground at the base of dying trees and lay their eggs in the roots.



Text Figure 13

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Curculionidae
(Wood-boring weevils)

Cossonus ponderosae Van D. (Gr., cossus, wood worm.) is a shiny black weevil found under the bark of trees infested with both the mountain pine beetle and the western pine beetle. It ranges in length from 5 to 6.5 mm. (1/4"). The larvae resemble bark beetle larvae in general appearance but are found in the sapwood. Little is known of the seasonal history of this or the other species listed here.

Cossonus crenatus (Horn)(L., crenatus, curved.) closely resembles the above species in color and general markings. In size it ranges from 4 to 4 mm. (1/6"). The immature stages are similar to those of the above species.

Adults can be found practically any time of the year in trees similar to those attacked by C. ponderosae. Their habits also appear to be identical, except that according to Van Dyke* they prefer drier situations than the above species.

Rhyncolus oregonensis Horn (Gr., rhinchos, snout + kolos, mutilated.) is a black weevil rather closely resembling the above species, but distinguished by the characters given in the key, p. 21, couplet 7. They range in size from 3.6 to 4.1 mm. (1/6").

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* Van Dyke, E. C. Species of Cossonus Cleirv. (Coleoptera) of America north of Mexico. Bul. Brook. Ent. Soc., 10: 1-23. 1915.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Coleoptera

Curculionidae
(Bark weevils)

Cylindrocopturus longulus (Lec.) is commonly found on the bark of bark beetle infested trees. See "sugar pine", p. 47.

Gelus californicus (Lec.)(Gr., gelos, matter for laughter.) is a small, cylindrical, scaly weevil 3 to 3.9 mm. (1/7") long. It is mottled grey on black with sometimes a shade of brown. There are usually two white spots on the sides of the pronotum and a single white spot near the end of the wing covers. In general appearance it closely resembles Cylindrocopturus but can be distinguished by the characters given in the key, couplet 4, p. 21. The larval characters are not known. The adults are frequently numerous in D. brevicomis and I. confusus galleries in June.

Pissodes yosemite Hopk. is common in the butt logs of dying trees, see "sugar pine", p. 11, for seasonal history.

Pissodes californicus Hopk. is reported attacking green trees. See p. 52.

Miscellaneous Beetles

Stephanopachys truncatus, S. substriatus, and S. pacificus have been collected from this host but little is known of their habits. See "sugar pine", p. 47.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Hymenoptera

Siricidae
(The horntails)

Sirex californicus (Ashm.), the California horntail is a uniformly metallic, greenish-blue wasp-like insect 25 to 31 mm. (1 1/6") long, (including ovipositor which extends not more than 1/5" beyond tip of abdomen) with the wing margins slightly smoky, and a smoky bar across the center of the fore-wings. Definitely known males are not at hand from which to draw a description. The tibiae and tarsi of the hind legs of the males of all Sirex are distinctly ganded.

The larvae are white, roughly cylindrical and usually hold themselves in an S-shaped position. The head is distinct and bent over sharply against the ventral surface of the prothorax; legs are wanting and the terminal abdominal segment is provided with a pointed black spine.

Little is known about the seasonal history. There is probably one generation a year. Adults have been collected in September on this host. Eggs are laid in the solid sapwood of freshly cut or dying trees by means of a "drill" or ovipositor. It takes as much or more than a half hour for the female to drill into the wood and lay her eggs. Occasionally the "drill" becomes stuck in the wood so firmly that the female is unable to remove it and dies, trapped by her own egg-laying efforts. On hatching, the larvae bore winding cylindrical galleries packed with fine frass in the solid sapwood and heartwood.

Within the Parks where trees are not considered as potential lumber, these insects may be considered beneficial in hastening decay as they open up the wood to moisture and fungi.

Sirex juvencus (L.) race cyaneus (L., cyaneus, blue.) is metallic blue-black, the legs except the basal segment are a red-brown, the wings slightly smoky. In length, they range from 20 to 38 mm. (1 1/5")(including ovipositor which extends not more than 1/5" beyond end of abdomen.) The males are similar except the last four abdominal segments are reddish-brown with a small patch of black at the anterior margin of each of these segments. The tibia and tarsi (except the last segment which is reddish) are black. In length, they range from 18 to 28 mm. (22/25").

Though it has been recorded from this tree, little else is known of its habits in this host.

Insects Affecting the Trunk or Branches

Hymenoptera

Siricidae
(The horntails) - Continued

Sirex behrensi (Cress.), Behren's horntail, has the head, thorax, and first two abdominal segments of both the male and female, a metallic blue-black; the remainder of the dorsal surface of the abdomen is a reddish brown. The wings of the females are smoky, of the males less so. In length, they range from 11 mm. (male) to 18 mm. (female) including ovipositor which extends less than 4 mm. (1/6") beyond tip of abdomen.

The characteristics for distinguishing the larvae from the other species are not known.

The habits are similar to S. californicus. Little is known of the seasonal history.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Lepidoptera
(Moths)

Vespamima sequoiae (Hy Edw.)(Gr. sphex, wasp + mimos, mimic), the Sequoia pitch moth,* belongs to a group known as the clear-wings, because except for the scales at the margin the wings are transparent. The body is black, except for the last three abdominal segments of the female and the last four of the male, which are broadly banded with yellow. The wing expanse is about 28 mm. (1"). To the casual observer the moths look distressingly like yellow-jackets. The larvae are about 30 mm. (1 1/5") long, the body ivory-white, the head shining brown.

Adults are in flight chiefly during July and lay their eggs usually in wounds of trees, but often on uninjured bark. The larvae on hatching, feed on the cambium causing the flow of large quantities of pitch, which in no way seems to bother the caterpillars. Pupae have been found in lodgepole pine in Yosemite National Park as late as July 20. It requires two years to develop from egg to adult.

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* Brunner, Josef. The Sequoia pitch moth, a menace to pine in western Montana. U.S.D.A. Bul. 111. 11 p., illus.

PONDEROSA PINE

Insects Affecting the Trunk or Branches

Isoptera

Kalotermitidae
(Termites)

Zootermopsis nevadensis (Hagen*)(Gr., zoion, animal + teredon, to rub + opsis, appears.), the Nevada termite, is dark brown; the winged caste about 12 mm. (1/2") long, not including the wings; the soldiers often 20 mm. (4/5") long.

This is the only termite found in trees infested with or recently abandoned by the western pine beetle. Swarming flights occur from May to September. Eggs are laid in the spring following the fall flight and eggs are about 1.4 mm. (1/25") in length but increase in size until just before hatching they are about 1.6 mm. long. The 15 to 22 eggs which generally make up the first laying hatch after an incubation period ranging from 48 to 60 days. The soldier caste develops in from 32 to 38 days after the first nymph hatches. The remainder of the developmental period is not well known.

This is one of the most interesting of the termite genera because of its wide distribution and its primitive habits. There is no worker caste, only the soldier and reproduction forms being developed. The reproductive form may develop into one of three types: the winged female, which is the most common type, the short-winged female, and the wingless female.

They should be considered as beneficial in that they help to hasten the decay of trees after they have been killed by bark beetles. It is common both in Yosemite and Sequoia National Parks.

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* Castle, Gordon B. The damp-wood termites.....(In Termites and termite control. Kofoid, C. A. and others. Uni. Calif. Press. 1934. p. 290-291.)

APPENDIX

BIOLOGICAL CONTROL

Parasitic and Predacious Insects

Insects are preyed upon extensively by their own kind. Consequently, a great amount of value as controlling agents is attributed to those doing the preying. It is probable that they are actually a more important factor in the control of the numbers of destructive insects than climatic factors which are usually considered to be the most important. This belief is open to question, however, as no extensive study has yet been made of the role played by native beneficial insects in the control of noxious forest insects.

With a few rare exceptions all insects feeding on other insects are predacious, that is they destroy their host. Among entomologists, however, insects that require but one individual to complete full growth are called parasites, and those that roam about feeding on several individuals, often of different species, are called predators.

The insects feeding on forest insects belong chiefly to three orders: Coleoptera (beetles), predators with few exceptions; Hymenoptera (wasps or four-winged flies), and Diptera (two-winged flies) among both of which are found predators and "parasites."

The beetles feed both during the adult and larval stage on a varied diet of insects.

The Hymenoptera feed chiefly in the larval stage; the egg being laid in or on the host by the parent, though sometimes it is laid distant from the host and the larva on hatching goes in search of it. When the host feeds exposed, as the pine butterfly for example, the parasite's egg is deposited inside the body, and when the host is concealed, the egg is laid upon the surface of the body, though in either case this is not a hard and fast rule.

The habits and developmental modifications in this order are fascinating. Some parasites lay a single egg that develops into often more than 150 larvae. This is called polyembryeny. Parasites may lay their eggs in other insect eggs--in some species the parasite's eggs hatch and the larvae develop in the host egg; in other species the parasite's egg does not hatch until after the host egg is hatched and the larva has reached the pupal stage. These eggs become lodged in a particular part of the host-larva anatomy such as a section of the nervous system.

Parasites of wood-boring or bark-boring insects generally pierce the infested portion with a remarkable apparatus called the ovipositor, which is made up of modified appendages of the abdomen. The apparatus is composed of two concave parts (lancets) fitted into a third (ventral valve) with semi-tongue and groove joints so each can be worked vertically independently of the other, and which together form a tube. The valve and lancets, in spite of their remarkably small size, can be worked through

bark or wood to the host. When the host has been reached an egg is forced down the ovipositor and placed on or in the body. Sometimes the host is first stung which paralyzes it, thus preventing further movement. Some parasites can form small tubes around their ovipositor, which when the host is pierced conducts the escaping liquid to the surface where the parasite feeds on it.

The problem of how the parasite locates the host which is often concealed by several inches of wood has not been solved.

"Parasites" are usually limited to one or two closely related hosts, though some species attack a wide variety of insects. Some parasites are parasites of parasites, and these parasites may in turn be parasitized. This sounds involved but a parasite is attracted to a particular host, (how, it is not known) and the fact that this particular host happens to be a parasite is beside the point. It seems to be merely a question of host relationship; the limiting factor appearing to be size, as a parasite is smaller than its host, rather than degree of parasitism.

The Diptera, which also feed chiefly in the larval stage both as predators and "parasites", are probably the most beneficial of the three orders and less is known of the habits than either of the other two groups.

There are a great many smaller predacious beetles found on and under the bark or in the wood of various trees dead or dying, from bark beetles or other causes. Some of the more common ones follow:

A - STAPHYLINIDAE (Rove-beetles): There are numerous genera and species in this family associated with wood inhabiting insects. Two of the most common are Nudobius pugetanus Casey, a black, very slender and active beetle about 7 mm. (7/25") long with very short reddish-brown win covers. The larvae are slender, extremely active, and white. Both stages are predacious. Phleonomus and several other closely appearing forms are about 3 mm. (1/8") long, dark with usually lighter wing covers. They are frequently found in bark beetle galleries in great numbers.

B - TENEBRIONIDAE: Corticeus substriatus (Lec.), is an evenly colored medium-brown beetle 4 to 4.9 mm. (1/6") long. The larvae are about 6 mm. (1/4") long, brownish and without a pair of hooks at the end of the abdomen. C. parallellus (Melsh.) and C. strublei Blais., closely resemble it in appearance. There are also several less common species. Both the adults and larvae of one specie , at least, prey on the eggs and smaller bark beetle larvae. Bius estriatus Muls. is 6 to 7.5 mm. (7/25") long, darker with a reddish brown pronotum and brown-black wing covers. The larvae and habits of either stage do not seem to be known.

C - CUCUJIDAE: Cucujus clavipes Fab. var. puniceus Mann. is a strongly flattened brick-red beetle 14 to 17 mm. (2/3") long. The larvae are also

flattened, brown, about 24 mm. (1") long, with a pair of upturned hooks at the end of the abdomen. Pupation occurs in a rounded cell made without using strips of wood fiber. Both stages are predacious. Laemophloeus sp. is a very small brown beetle, about 1/12" long, that is not very common.

D - OSTOMATIDAE: Temnochila virescens (Fab.) var. chlorodia (Mann.), the common "Gilmore bug", is a blue-green beetle that walks with a very jerky movement. It is 10 to 21 mm. (3/5") long. The larvae are greyish to purplish white, with dark brown heads, and dark brown plates on the upper surface of the first three thoracic segments. There is a single large plate on the first two segments, and two smaller plates on the third segment (fig. 43). When full grown, the larvae are about 25 mm. (1") long. Both stages are predacious. Coricotomus caviceps (Fall) is 4 to 6 mm. (1/5") long, slender, head and thorax dark brown, wing-covers lighter, mandibles distinct. The larvae look like small Temnochila larvae. Both stages are supposedly predacious. Tenebroides is 7 to 11 mm. (3/8") long, dark brown, flattened; the thorax much wider in front than behind. The larvae resemble Temnochila larvae. Both stages are predacious. T. sinuatus (Lec.) occurs in the Sierra region. Ostoma ferruginea (L.), is about 9 mm. (3/8") long, flattened, broadly oval, uniformly light reddish-brown in color. The larvae have a pair of only rudimentary processes (hooks) at the end of the abdomen. The habits are not well known. It has not been collected from sugar pine but is common in dying ponderosa pine. Airora bicolor Csy. is a narrow, elongate dark brown beetle 5.4 to 6.1 mm. (1/4") long. The head and pronotum are a reddish brown, the latter finely punctured with a fine ridge close to the lateral margins. The wing covers are faintly ridged. The larvae resemble Temnochila larvae, except that the plate on the top of the second thoracic segment is nearly divided and the hooks at the end of the body do not arise from a definite plate. Both stages are probably predacious.

E - COLYDIIDAE: Aulonium longum Lec. is 5 to 6.5 mm. (1/4") long, uniformly brown, and with two ridges at the anterior part of the pronotum. The wing covers are smooth. The larvae are ivory white, no plate on the thorax and about 5.5 mm. long. The terminal abdominal segment has a pair of upturned hooks arising from the end of a roughly surfaced, hardened area. The adults and larvae are predacious. Deretaphrus oregonensis Horn is slender, dark brown with strongly ridged wing covers, and 8 to 13 mm. (1/2") long. The larvae according to Craighead are parasitic or wood-boring larvae and spin a cocoon in which to pupate. Lasconotus laqueatus Lec. is 2.5 to 3.1 mm. (1/12") long, brown, with ridged wing covers and hollowed out and laterally ridged pronotum. The larvae resemble very small Aulonium larvae. Both stages are probably predacious and at times quite common. There are several other species rather difficult to separate because of their small size.

Parasitic and Predacious Insects

F - HISTERIDAE: Platysoma punctigerum Lec. is a somewhat flattened, shiny, jet black beetle 3.8 to 4.2 mm. (1/6") long. The larvae are slender, white, very active, and about 9 mm. (3/8") long. The head and first thoracic segments are deep brown. Both stages are predacious. Plegaderus nitidus is a very shiny, dark-brown, nearly circular beetle 1.5 to 2 mm. (2/25") long. The pronotum has a sharp groove on each side. The larvae are not well known. Both stages are predacious.

G - ELATERIDAE (Click beetles): Many of these beetles are predacious though this is not generally known. Alaus melanops Lec., the eyed click beetle is greyish black or black mottled with white and are 24 to 38 mm. (1 1/4") long. The larvae are flattened yellowish brown with dark brown head and first thoracic segment. The terminal segment bears a pair of irregular roughened hooks. The larvae only are known to be predacious. They prey on insects boring in decaying wood.

H - CLERIDAE: The species of this family are very commonly associated with bark beetles and probably the most beneficial beetles in their control. Enoclerus sphegeus Fab. is 10 to 12.5 mm. (1/2") long; head, thorax, legs, and wing covers are black and covered with long greyish black hairs; a wide grey band of hairs crosses the wing covers near the center. The abdomen is red. The full grown larvae are about 20 mm. (4/5") long. They resemble the larva of Temnochila but can be distinguished by the pair of light brown spots on the second thoracic segment. Both stages are predacious. The adults are most common on infested trees very early in spring. Pupation generally occurs at the base of the tree in the bark scales or in the duff close by the tree in an oval cell coated with a silvery or aluminum colored substance. Enoclerus lecontei (Wolc.), is 6 to 8 mm. long, the head, thorax, legs, and abdomen black, the wing covers greyish at the base and tips, and crossed at the middle with a distinct black band. The larvae are practically indistinguishable from the preceding species and similar in habits.

I - OTHNIIDAE: Othnius lugubris Horn is a metallic grey, very active beetle with prominent eyes. It is about 5 mm (1/5") long. The larvae are yellowish white with caudal hooks of the shape shown in Fig. 1 The habits are imperfectly known.

J - RHIZOPHAGIDAE: Rhizophagus sculpturatus Mann. is a narrow, dark brown predator 2.9 to 4 mm. (1/8") long. The pronotum is generally somewhat darker than the wing covers. The larvae are whitish with only small terminal hooks on the abdomen. The larvae are probably predacious. LATHRIDIIDAE: Corticaria serrata (Payk.) is a very small light brown beetle, common on infested trees. It ranges in length from 1.2 to 1.7 mm. (1/13"). The larvae are not known. NITIDULIDAE: Epurea sp. feeds on bark beetle larvae. It is about 3.5 mm. (1/8") long, brownish yellow in color and the wing covers do not completely conceal the end of the abdomen.

Parasitic and Predacious Insects

K - RAPHIDIIDAE: There are several species of Raphidia of which R. adnixa Hagen is probably the most common. Little is known of the seasonal history of the species. The females are about 15 mm. long including the terminal process and dark brown; the wings with distinct veins. The larvae are slender, about 15 mm. (3/5") long, purplish, the head and first thoracic segment shiny dark brown, the rest of the body purplish, and widest at about the middle. The thorax narrows appreciably between the first and second segment. The larvae are predacious, the adults probably so.

DIPTERA
(Flies)

Some of the more common species associated with bark beetles are:

L - DOLICHOPODIDAE: Medetera spp. are greyish flies somewhat smaller than a house-fly, which lay their eggs on the bark or in the beetle holes of infested limbs. They are especially common on newly attacked trees. On hatching, the larvae work into the cambium and feed on bark beetle eggs of any larvae chanced upon. The larvae are white, cylindrical, and when full grown are about 1/3" long.

M - LONCHAEIDAE: Lonchaea spp. are greenish flies about 1/6" long, which lay their eggs in the beetle holes of infested trees. The larvae are white and taper rapidly towards the head. They feed on bark beetle larvae but also seem to be able to live on fungi or decaying wood.

N - SCENOPINIDAE: Pseudatrichia sp. or a closely allied insect is fairly common in the larval stage under the bark of sugar pine. The larvae are extremely long for their width, usually over 3/5" long and about 1/25" wide. The body is subdivided so there appears to be about 20 segments. The head is small, oval and brown. The pupa is brown, about 1/3" long, with a row of spines on the abdominal segments.

O - CECIDOMYIIDAE: These are small gnat-like insects that lay their eggs in infested trees. The larvae are about 1/6" long, usually pinkish, and often found in clusters. They are not predacious.

P - ASILIDAE: The larvae of several species of this family are found under the bark and in the wood feeding on round-head and flat-head larvae. The larvae look considerably like round-head larvae and can be easily mistaken for them. In the adult stage the insects are known as robber-flies and prey on various other insects.

Parasitic and Predacious Insects

DIPTERA - Continued

Q - STRATIOMYIIDAE: The larvae of these flies are peculiar in that the "skin" is heavily impregnated with calcium. They are bristly, flattened, and brown or greyish brown in color and when full grown are about 1/4" long. The adults are dull bluish-black with the wing veins reduced and present only at the anterior margin.

R - RHAGIONIDAE: The larvae of Xylophagus are cylindrical, ivory-white, with a very dark brown to nearly black, prominent, sharply pointed head, and a similarly colored hardened area at the end of the abdomen, from which a pair of hooks project. The upper surface of the thoracic segments are varyingly marked with dark brown areas. When full grown, the larvae are about an inch in length. The pupae are yellowish brown, 4/5" long. The adults are 3/5" long, nearly black, with dull red areas at the base of the first two or three abdominal segments. The larvae occur under the bark of sugar pine and prey on any subcortical life they chance upon.

HYMENOPTERA

The following families include the most common "parasites":

S - BRACONIDAE: Most of the parasites of bark beetles belong to this and the following family. Coeloides dendroctoni Cushm., one of the most common insects parasitic on the larvae of Dendroctonus monticolae and various species of Ips, is dark brown with reddish abdomen and about 1/4" long. The eggs are laid on the host larvae by means of an ovipositor that bores through the bark to the larvae below. When feeding is finished, the larvae always spin white or tan, oval cocoons. After transforming to adults, the parasites chew their way out through the bark.

T - PTEROMALIDAE: The insects in this family are all small, seldom being over 1/4" long, and often very much less. They are usually green with yellowish colored legs, and the wings lack veins except one that ends in a knob at the anterior margin of the fore-wing. These more common species can be distinguished by the characters given in the key, (p. 29); the larvae have very minute hairs. None of the larvae spin cocoons in which to pupate.

U - EURYTOMIDAE: Eurytoma is a black insect but otherwise resembles the parasites in the above family in general appearance and size. The female lays her eggs chiefly on other parasite larvae. The larvae are distinctly hairy, with prominent black mandibles. They do not spin cocoons.

Parasitic and Predacious Insects

HYMENOPTERA - Continued

V - CYNIPIDAE: Ibalia spp. are parasitic on horntail larvae.* The head and thorax are jet black, the abdomen extremely compressed and brown. In length, they average about 3/8". To find a host larvae in which to lay her eggs, the female located by the use of her antennae the hole made in the bark by the ovipositor of a horntail. When one is discovered, she forces her ovipositor down this channel until it reaches the young horntail larvae which is then pierced, and injected with an egg that has been forced down the hollow ovipositor. The egg does not hatch until the host larva has grown considerably; it may be as long as nearly a year before it hatches; after hatching, the larva consumes its host, and then pupates without spinning a cocoon.

PSEUDOSCORPIONIDA

W - Very little is known of these interesting insect relatives though they are very common under the bark of infested ponderosa and sugar pine. When full grown they are slightly over 1/5" long, with dark brown "pincers" and brown abdomen. They are reported to be carnivorous but probably do not affect the brood of any of the bark beetles though they are commonly found clinging to the legs or under the wing covers of various wood boring beetles.

* Chrystal, R. N. Studies of the Sirex parasites. Illus. Oxford. For. Man. No. 11, 63 p., 10 pl., 1930.

EXPLANATION OF FIGURES

All Figures Greatly Enlarged

Fig. 1. Typical larva of moth or butterfly showing presence of true legs on first three segments (the thorax) behind the head, and absence of prolegs from the first two abdominal segments. (All the segments behind the thorax constitute the abdomen. With the insects, the thoracic segments are the only segments that bear true legs.)

2. Typical sawfly larva showing presence of prolegs on 2nd abdominal segment.

3. Monochamus maculosus, larva: Dorsal view of 4th and 5th abdominal segments showing blister-like warts (ampullae) on ambulatory pads. For full drawing of larva see p. 45.

4. Acanthocinus obliquus, larva: Dorsal view of 4th and 5th abdominal segments showing absence of blister-like warts.

5. Chrysobothris dentipes, adult: Ventral view of prothorax showing produced but pointed prosternum.

6. Chalcophora angulicollis, adult: Ventral view of prothorax showing produced but blunt prosternum.

7. Callidium antennatum, adult: Ventral view of prothorax showing prosternum not produced.

8. Alaus melanops, larva: Dorsal view of last abdominal segment showing terminal hooks.

9. Asemum sp., larva: Dorsal view showing margin of epicranial halves of head partly fused behind the front. After Craighead.

10. Stenocorus sp., larva: Dorsal view showing margin of epicranial halves of head separated behind front. After Craighead.

11. Melanophila californica: Dorsal view of first thoracic segment. The head is not shown completed. For full drawing of a flat-head larva see p. 38, 11A, ventral view of same segment. See also Fig. 15.

12. Dicerca tenebrosa: Dorsal view of first thoracic segment; 12A, ventral view.

13. Anthaxia aeneogaster: Dorsal view of first thoracic segment; 13A, ventral view.

14. Buprestis aurulenta: Dorsal view of first thoracic segment; 14A, ventral view.

15. Melanophila gentilis: Dorsal view of first thoracic segment; 15A, ventral view. Compare with Fig. 11.

16. Chrysobothris monticola: Dorsal view of first thoracic segment; 16A, ventral view.

17. Chrysophana placida: Dorsal view of first thoracic segment; 17A, ventral view.

18. Ergates spiculatus, larva: Dorsal view of part of head.

19. Anthaxia aeneogaster, adult: Dorsal view showing nearly straight basal margin (heavy line) of pronotum. Compare with basal margin of pronotum of Melanophila, Text fig. 2, p. 38.

20. Chrysobothris contigua, adult: Fore-leg showing spine near distal end of tarsus.

21. Chrysobothris dentipes, adult: Fore-leg showing distal end enlarged but no spine.

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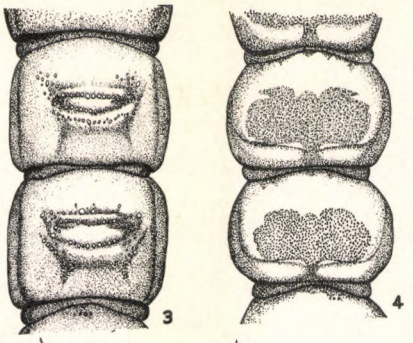
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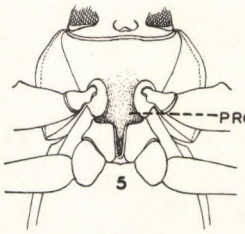

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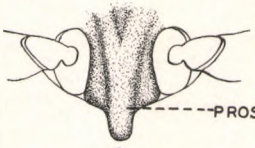

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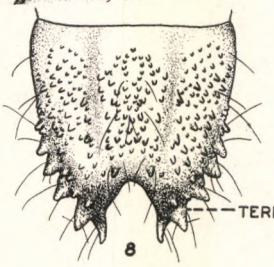

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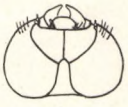
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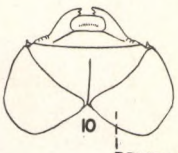

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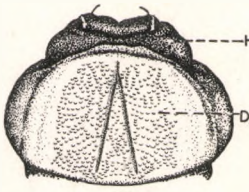

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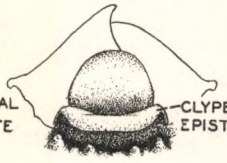

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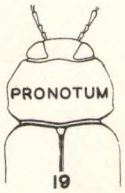

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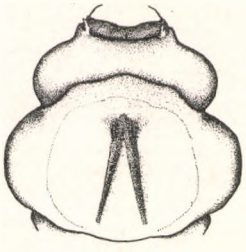
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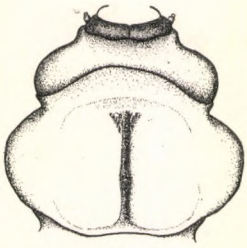
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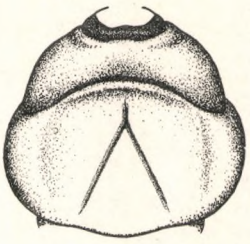
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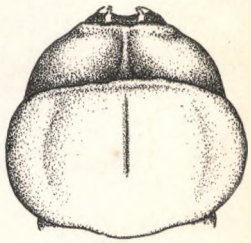
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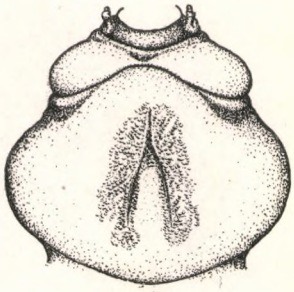
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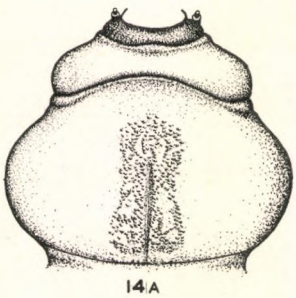
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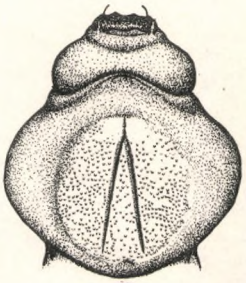
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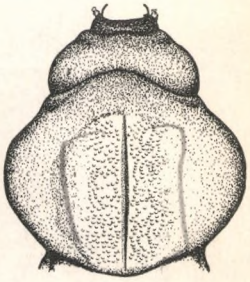
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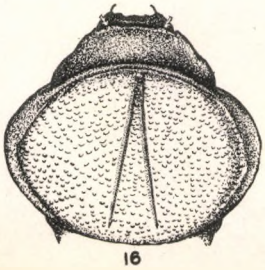
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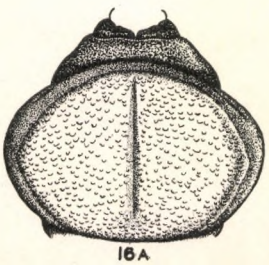
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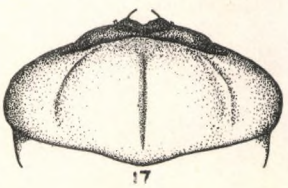
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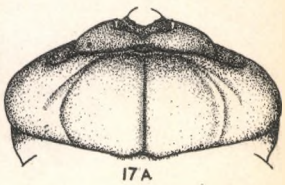
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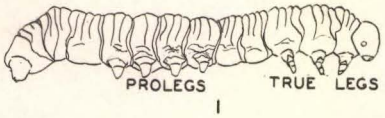

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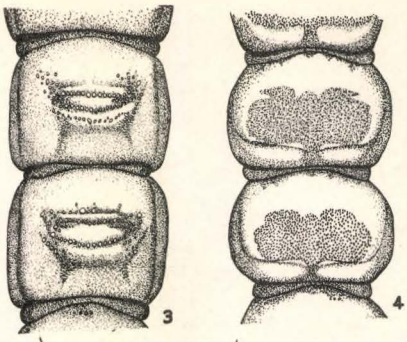
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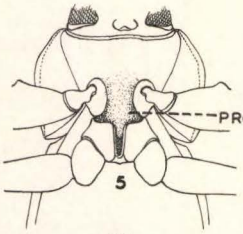

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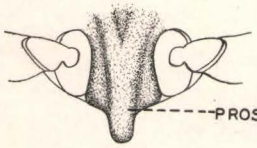

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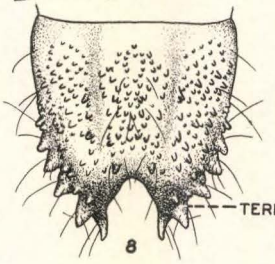

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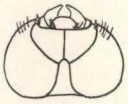
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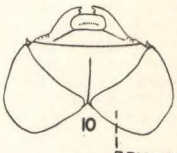
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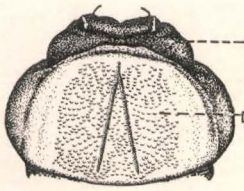

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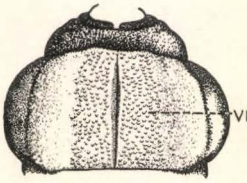

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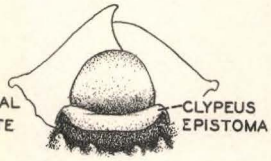

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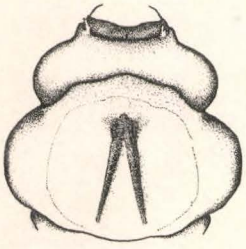
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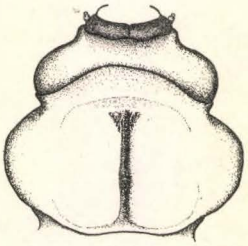
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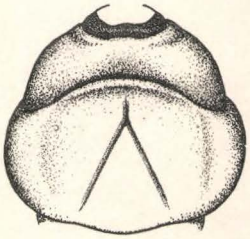
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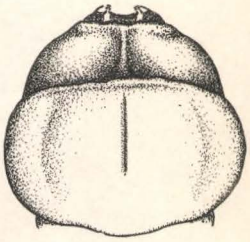
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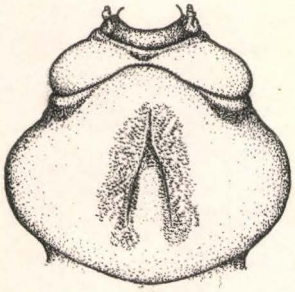
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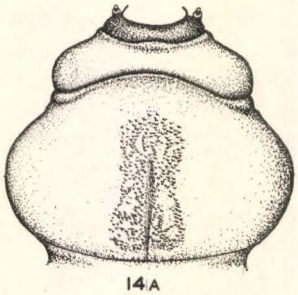
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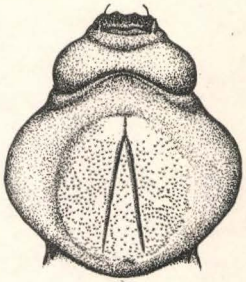
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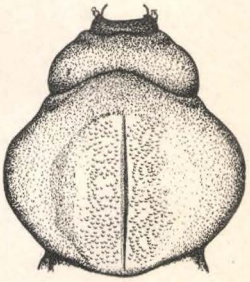
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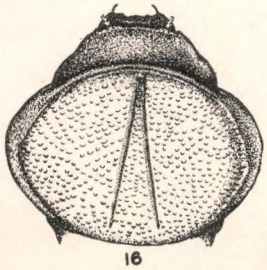
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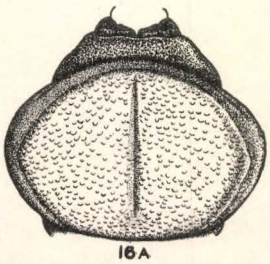
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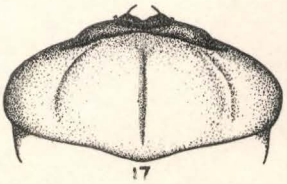
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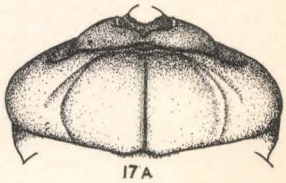
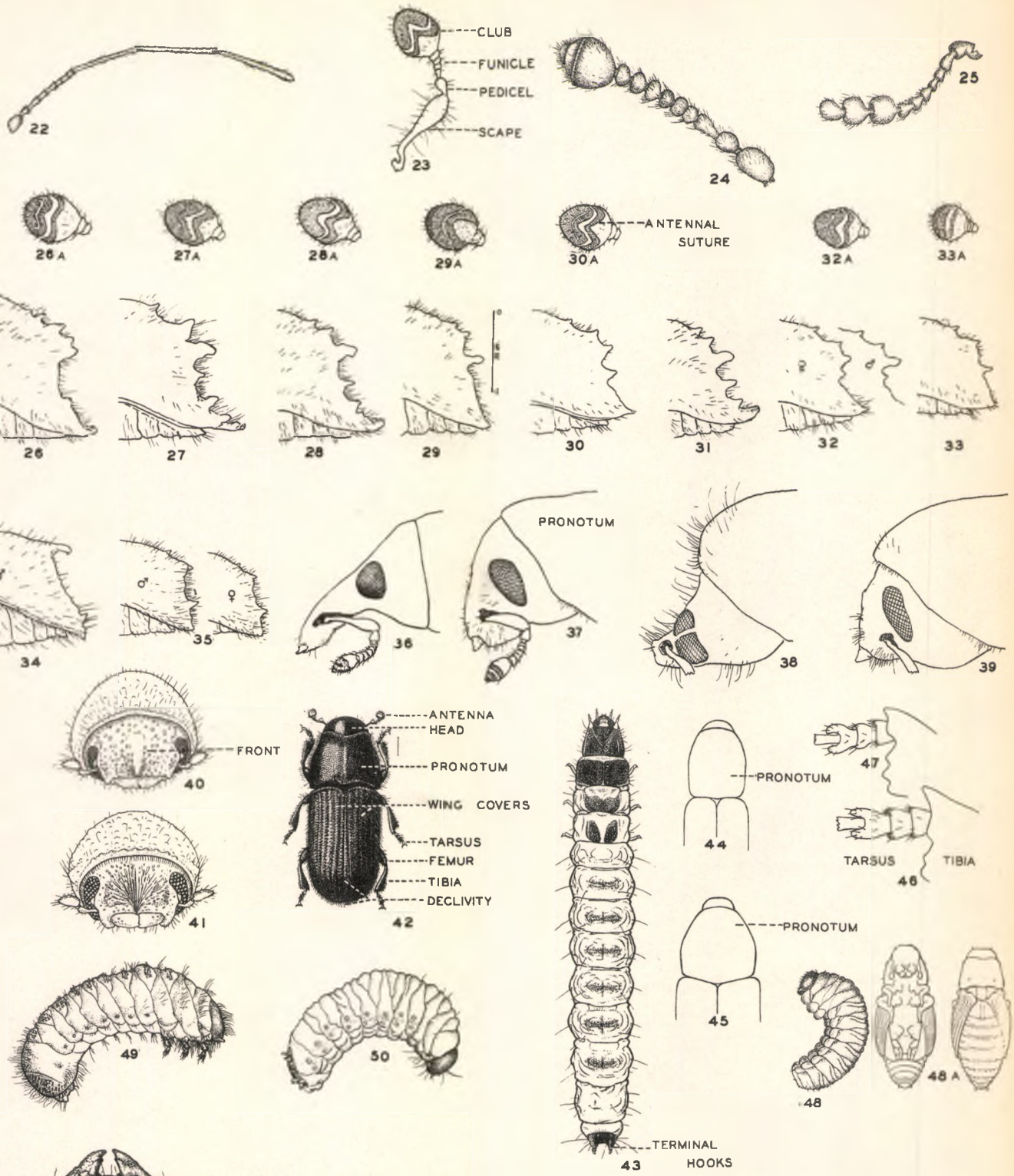

17A

EXPLANATION OF FIGURES

All Figures Greatly Enlarged

22. Ernobius pallitarsis, adult: Antenna (filiform type).
23. Ips confusus, adult: Antenna (clubbed and elbowed type).
24. Rhizophagus sculpturatus, adult: Antenna (clubbed; not elbowed type).
25. Stephanopachys pacificus, adult: Antenna (club not consolidated; not elbowed type).
26. Ips emarginatus, adult: Lateral view of declivity showing arrangement of teeth. 26A, club of antenna. For full drawing of an Ips see Pl. 1, A.
27. Ips ponderosae, adult: Lateral view of declivity. 27A, club of antenna.
28. Ips vancouveri, adult: Lateral view of declivity. 28A, club of antenna.
29. Ips coniferus, adult: Lateral view of declivity. 29A, club of antenna.
30. Ips integer, adult: Lateral view of declivity. 30A, club of antenna.
31. Ips confusus, adult: Lateral view of declivity. 23, antenna.
32. Ips oregoni, adult: Lateral view of declivity of female (left) and male (right). 32A, club of antenna.
33. Ips latidens, adult: Lateral view of declivity. 33A, club of antenna.
34. Pityogenes carinulatus, adult: Lateral view of declivity of male. Teeth of female much smaller.
35. Pityokteines elegans, adult: Lateral view of declivity of male (left female (right).
36. Cossonus crenatus, adult weevil: Lateral view of head. Note elbowed antenna.
37. Hylastes gracilis, adult bark beetle: Lateral view of head.
38. Trypodendron ponderosae, adult: Lateral view of head.
39. Ips emarginatus, adult: Lateral view of head.
40. Gnathotrichus retusus, adult: Front view of head.
41. Gnathotrichus sulcatus, adult: Front view of head.
42. Dendroctonus valens, adult: Principal parts of a beetle named.
43. Temnochila virescens, larva: Dorsal view.
44. Hylastes gracilis, adult: Showing shape of pronotum.
45. Hylurgops porosus, adult: Showing shape of pronotum.
46. Hylastes macer, adult: Showing shape of third fore-tarsal segment of leg.
47. Hylurgops porosus, adult: Showing shape of third fore-tarsal segment of leg.
48. Dendroctonus brevicomis, larva: Lateral view. 48A, pupa (left, ventral view; right, dorsal view).
49. Ernobius pallitarsis, larva: Lateral view, note legs on thorax; note also spines on dorsal surface of most of the body segments.
50. Dendroctonus valens, larva: Lateral view. Note plate on body segments 11 and 12.
51. Dendroctonus monticolae, larva: View of head. The dark area (front) is not as dark in relation to rest of head capsule as is shown. It is practically same color as rest of head capsule, i.e. medium brown. It was necessary to darken this part to show the transverse swelling more clearly.
52. Ips confusus, larva: View of head. Front also darker than natural, actually about same color as in D. monticolae.
53. Pissodes yosemite, larva: View of head. Color of front as indicated.
54. Magdalis lecontei, larva: View of head. Color of front as indicated; note that it is much narrower than the front of the three preceding species.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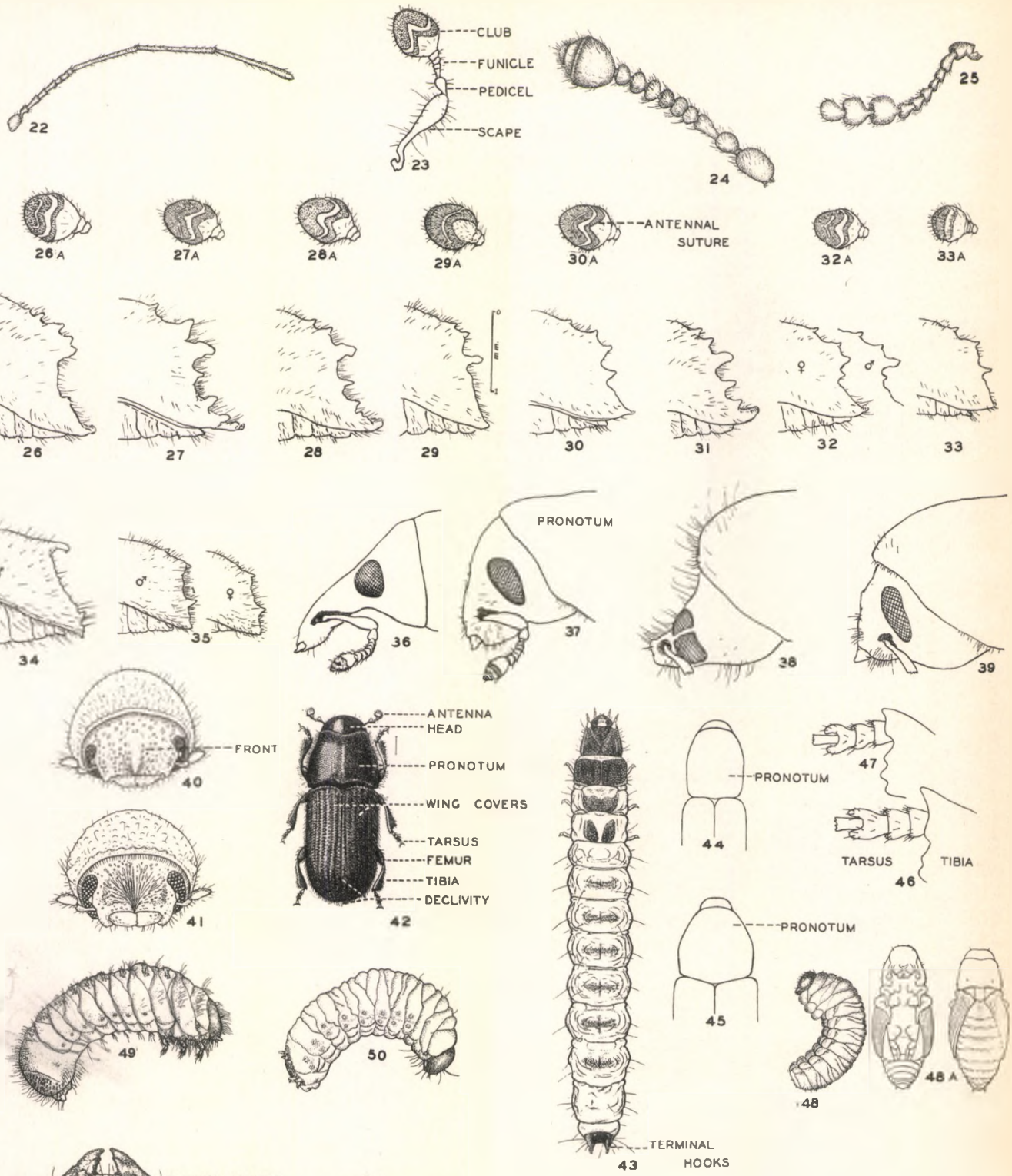
SCAPE
ANTENNAL SUTURE
PRONOTUM
FRONT
ANTENNA
HEAD
PRONOTUM
WING COVERS
TARSUS
FEMUR
TIBIA
DECLIVITY
TARSUS
TIBIA
TERMINAL HOOKS
MANDIBLE
FRONT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TIBIA
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TERMINAL HOOKS
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DRAWINGS SHOWING

INSECT CONTROL METHODS

USED AGAINST BARK BEETLES

IN THE

WESTERN NATIONAL PARKS AND FORESTS

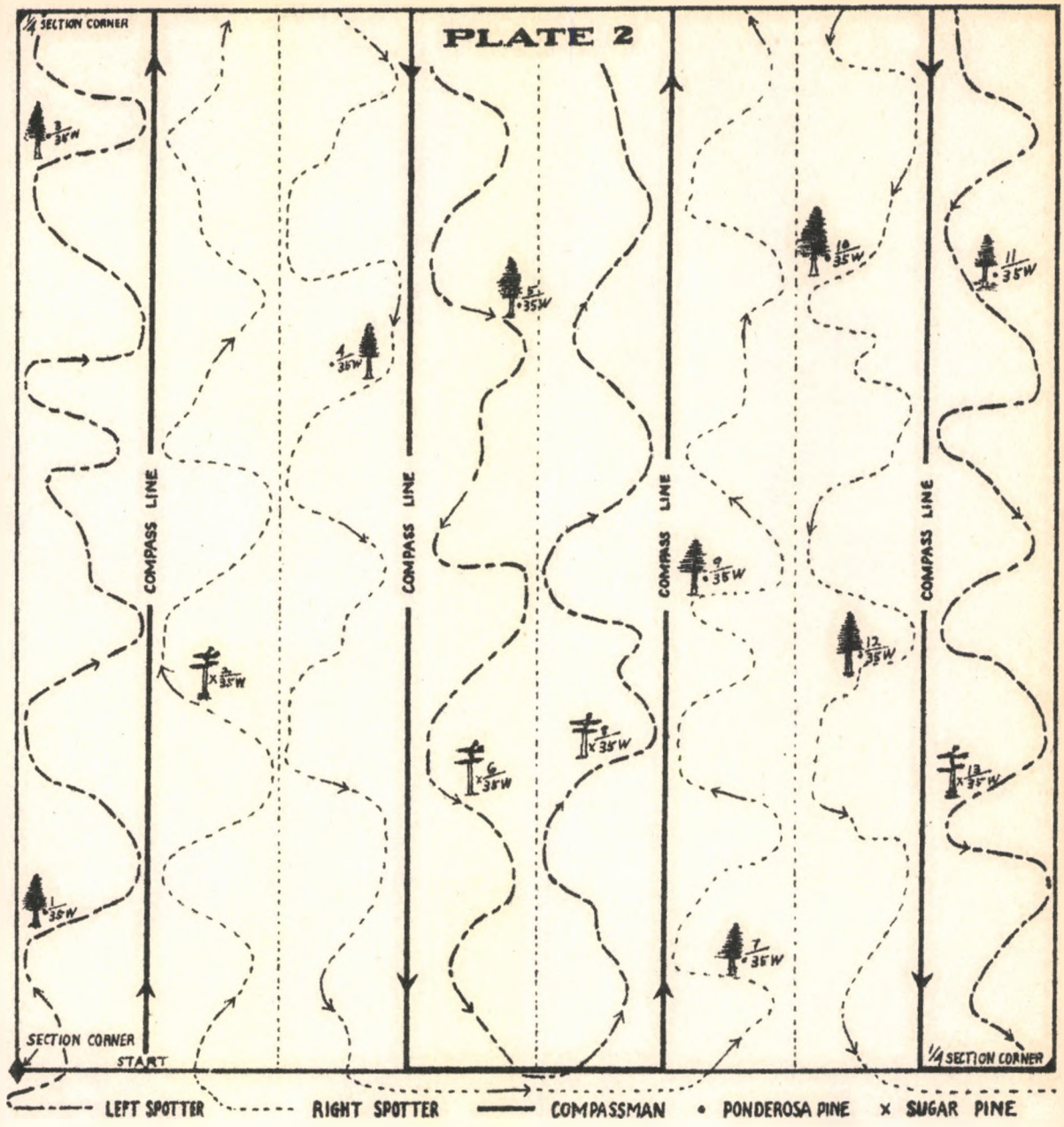
Prepared by the Branch of Forestry,
National Park Service, in Cooperation with
the Division of Forest Insects U. S. Bureau of Entomology
and Plant Quarantine, and the SERA, Project 3-F2-678
Berkeley, California
April 1, 1935

PLATE 1

SPOTTING CREW IN THE FIELD

The compassman (man in center) runs compass lines through the infested areas, making a rough map as he goes showing the ridges, trails, and the position of each infested tree located by the spotters. Each spotter takes a strip of definite width on each side of the compassman and examines all trees within this strip that show signs of being infested.

PLATE 2



Diagrammatic view showing the method of gridironing a section (only ¼ section is shown) to locate the infested trees. The compassman starts 5 chains from the section corner and runs a compass line due north. The spotters on each side of the compassman move along even with him and each covers a strip 5 chains wide examining all trees that look as though they were infested. On reaching the end of the section the compassman turns off a right angle, goes ten chains east along the section line, then turns off another right angle, and returns, running his compass line due south until he reaches the section line from which he started. The spotters keep the same position on each side of the compassman as shown in the diagram, and in this way the entire section is covered. With average going, a spotting crew can cover about half a section a day. The compassman keeps record of the distance covered by pacing.

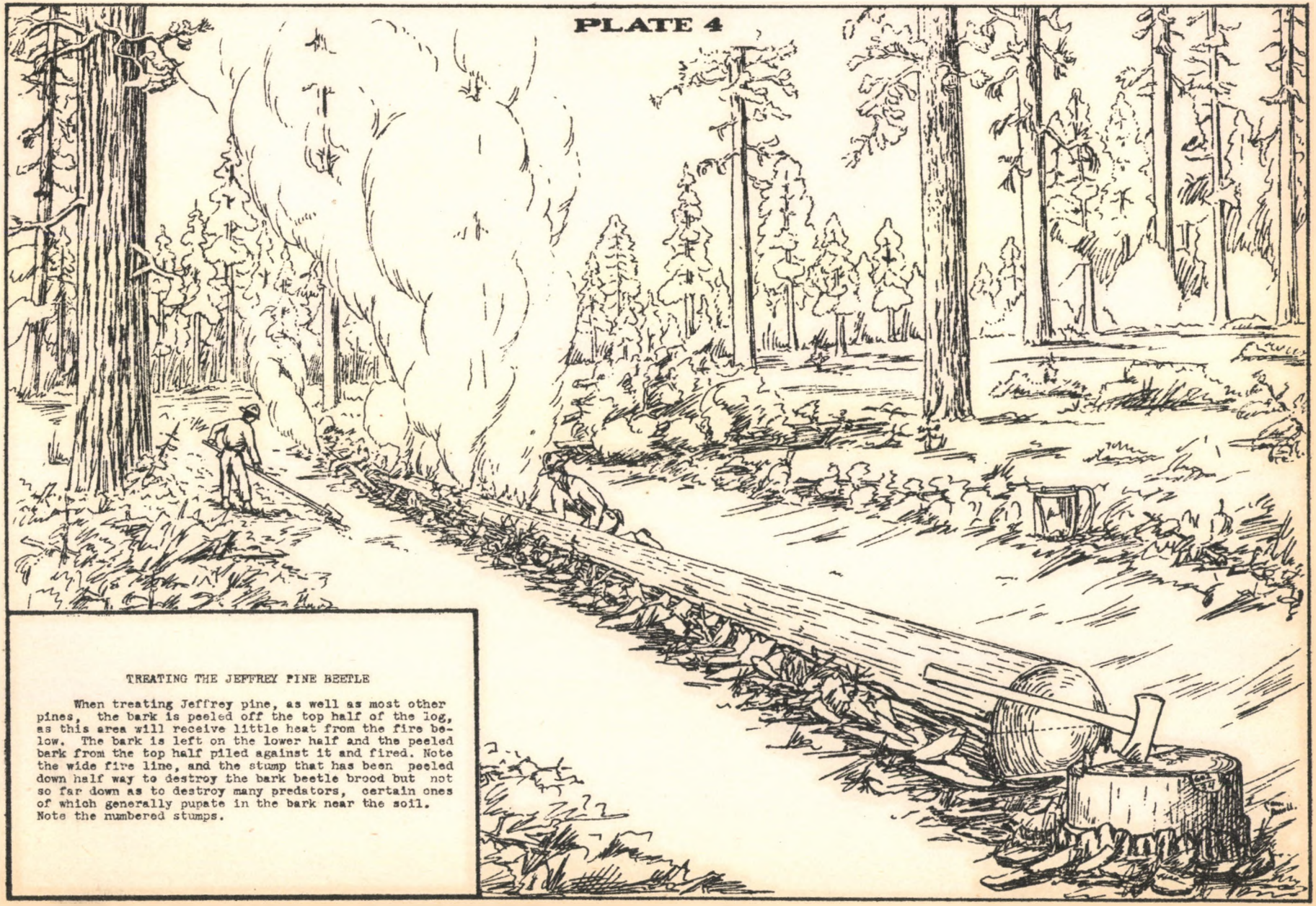
MARKING AN INFESTED TREE

When an infested tree is located by one of the spotters, he calls out to the compassman for the number to be put on the tree. The spotter then blazes the tree above his head on three or four sides so that the blazes will not be hidden by underbush, and that at least one of the blazes will be seen from which ever side the treating foreman approaches.

The tree number is marked in, on one of the blazes, in the form of a fraction; the number above the line being the tree number; the number below, the year of attack (1934 in this case). The "S" following the "34" stands for "summer" and shows that the beetles attacked the tree during spring or early summer and will emerge before fall. If spotting were being done during the late fall or early spring the letter "W" (winter) would have been used as it means that the beetles will pass or have already passed the winter in the tree. This information is necessary as it helps to show the trend of the infestation and also serves as a check on the spotters understanding of the job.

The spotter also fills out a tree tag on which he gives the full tree number, date of spotting, kind of insects in tree, tree species, and other necessary information. The tag is then folded and placed tightly in a slit made in the bark. When the treating foreman comes to cut the tree, he takes the tag, marks in the date of treating and infested length, and each evening turns in the tags from all the trees he has treated that day to the camp foreman who checks the tags off against the compassman's spotting record, thus showing what trees have been treated.

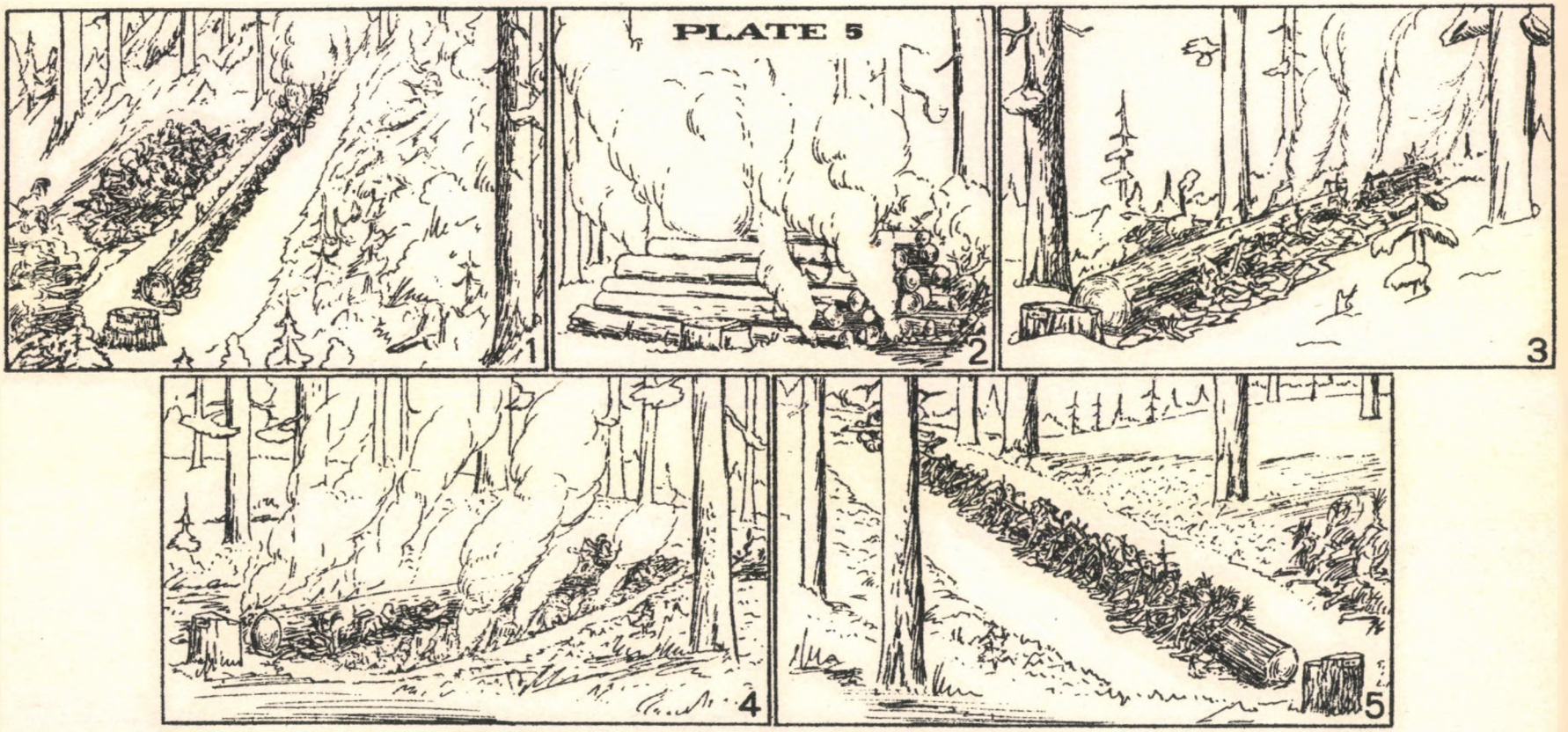
PLATE 4



TREATING THE JEFFREY PINE BEETLE

When treating Jeffrey pine, as well as most other pines, the bark is peeled off the top half of the log, as this area will receive little heat from the fire below. The bark is left on the lower half and the peeled bark from the top half piled against it and fired. Note the wide fire line, and the stump that has been peeled down half way to destroy the bark beetle brood but not so far down as to destroy many predators, certain ones of which generally pupate in the bark near the soil. Note the numbered stumps.

PLATE 5



HINTS FOR BETTER BURNING

Figure 1. When treating on a slope, always drop the tree up hill. After the bark has been peeled off the upper portion, it is piled close along the sides with a few limbs, and the fire started at the upper end of the log. As fire burns more slowly down than up, there is less chance of it escaping, or scorching nearby trees. The top of the tree usually breaks and can be thrown back alongside the trunk thus shortening the fire line.

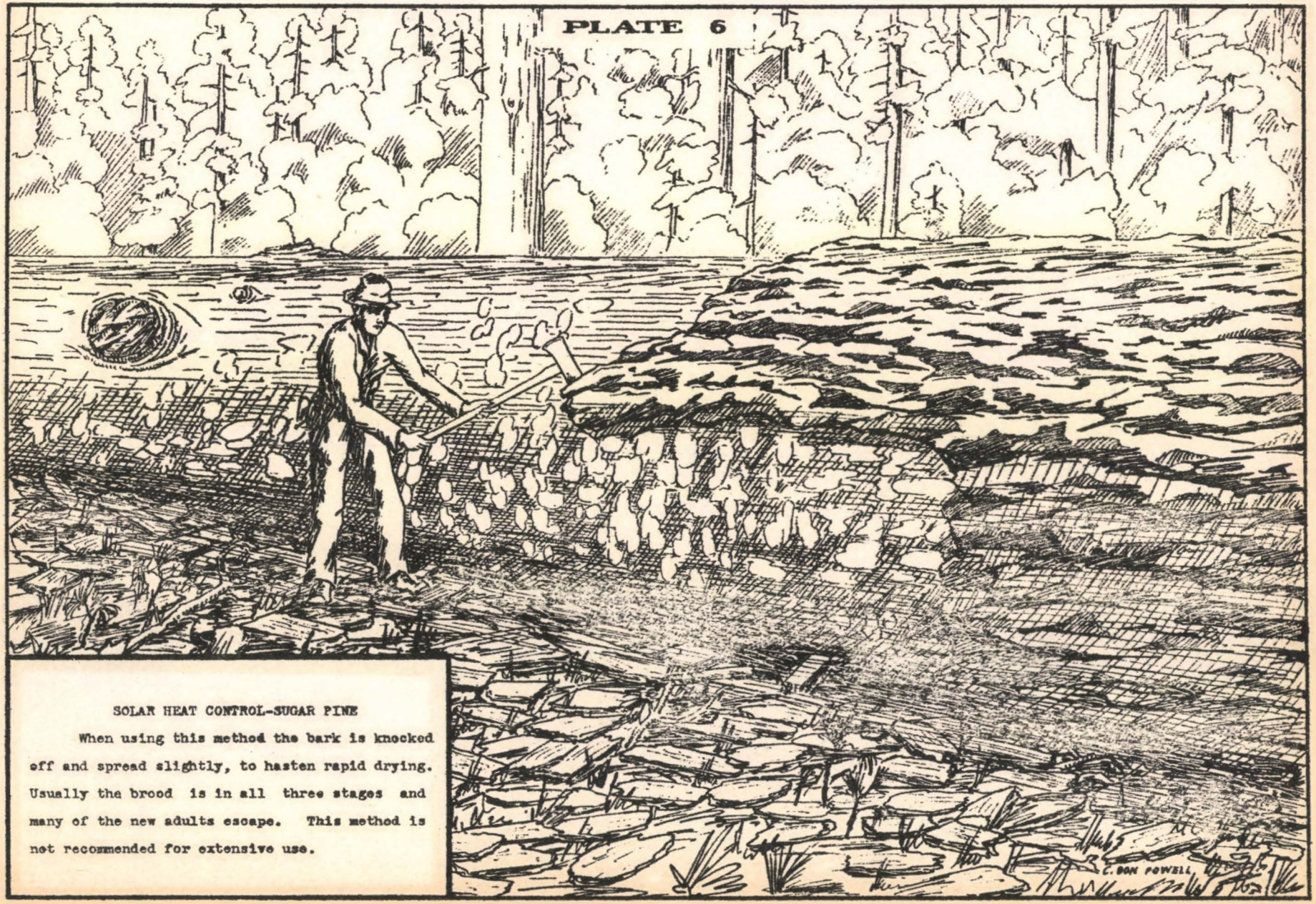
Figure 2. When treating smaller trees they can often be cut into 16 foot logs, decked, and fired. This saves considerable time as only a single fire line is required. An open spot should be found where the large fire will scorch no trees.

Figure 3. During winter treatment, the fire lines can be built much closer to the tree trunk, and less precautions are necessary as very little scorching occurs during the winter burning.

Figure 4. Towards the end of spring control jobs, conditions are often so dry that a fire is hazardous. When there are a few trees left to burn, this method is used. The fire line is placed around the tree some distance from it and a back fire started, which when it burns up to the prepared tree, has made a good wide safety zone.

Figure 5. In some cases it is often practicable to place limbs over the log in order to draw the fire around the bole and scorch the upper surface. This method is used chiefly where the bark is very tight, there is little fire hazard, and most important, where the trees are not very large.

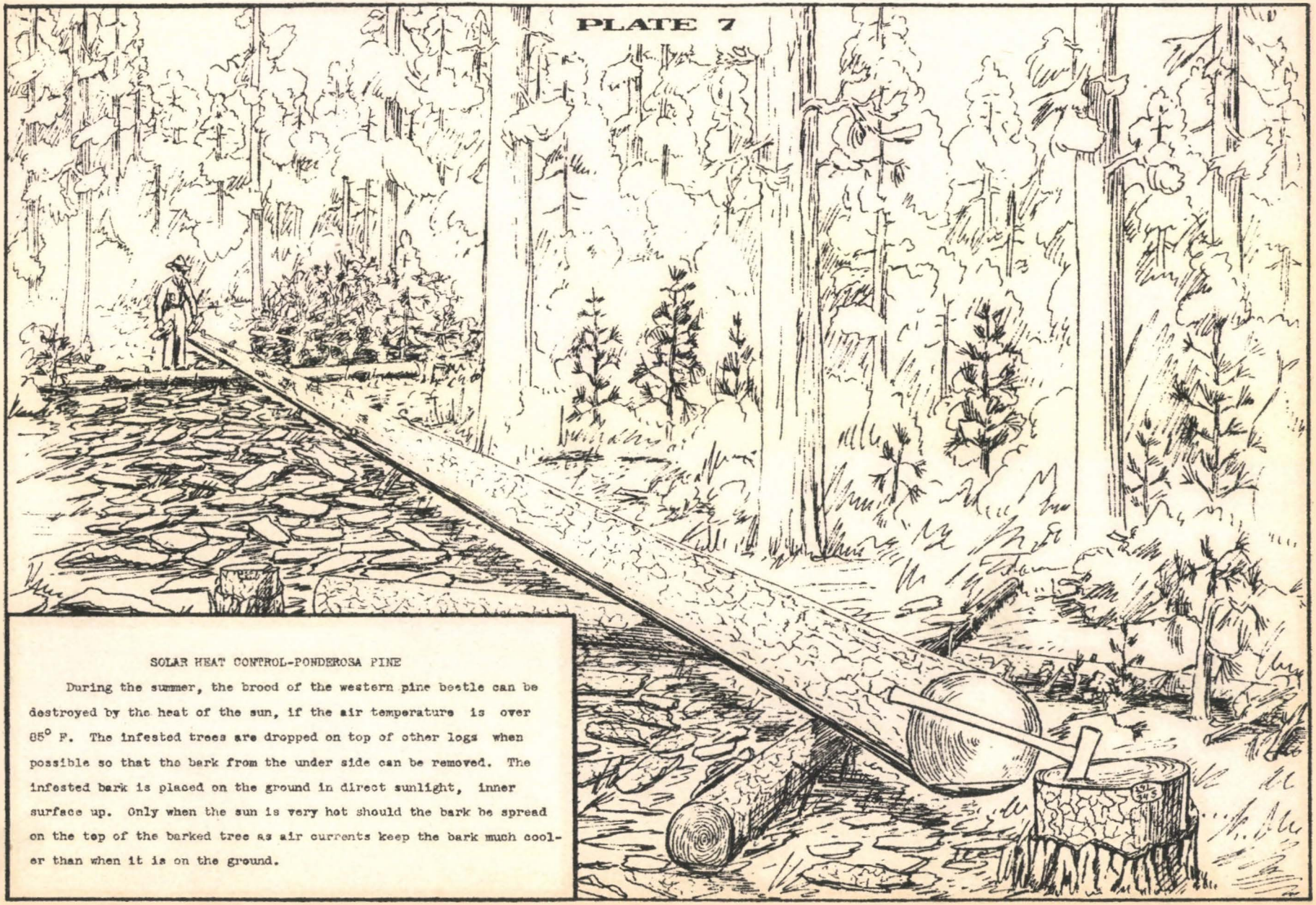
PLATE 6



SOLAR HEAT CONTROL-SUGAR PINE

When using this method the bark is knocked off and spread slightly, to hasten rapid drying. Usually the brood is in all three stages and many of the new adults escape. This method is not recommended for extensive use.

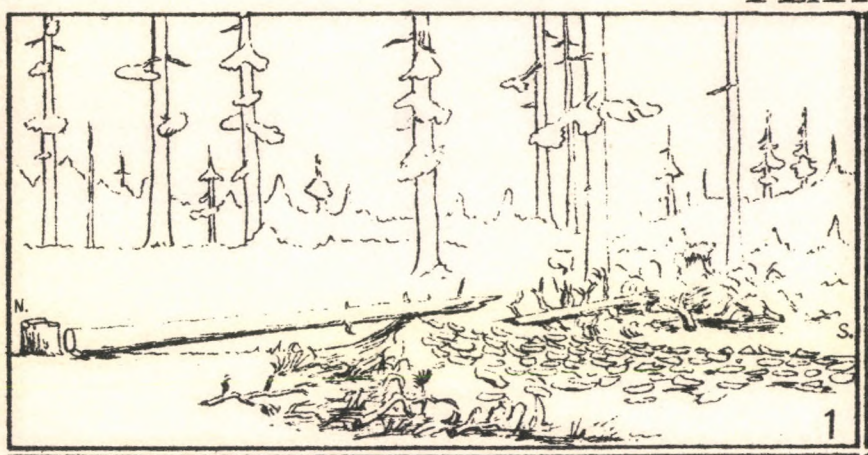
PLATE 7

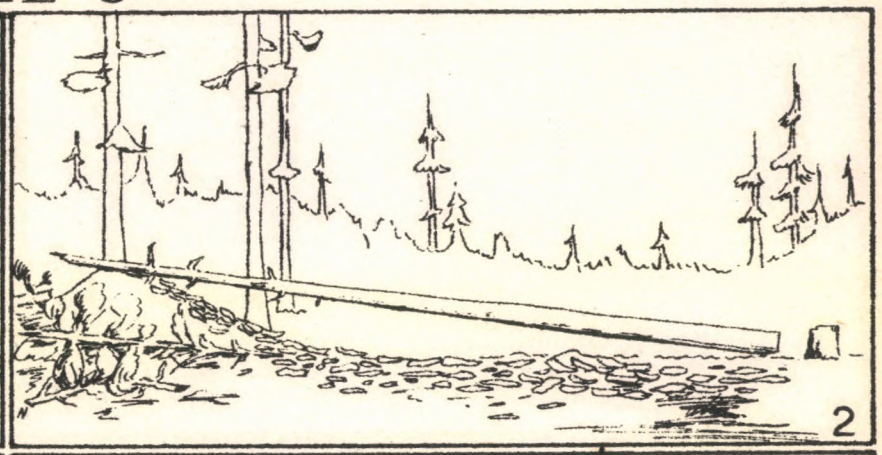


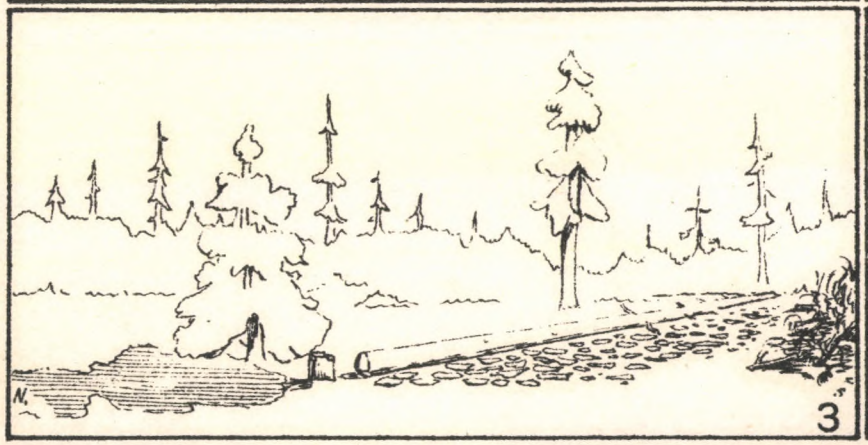
SOLAR HEAT CONTROL-PONDEROSA PINE

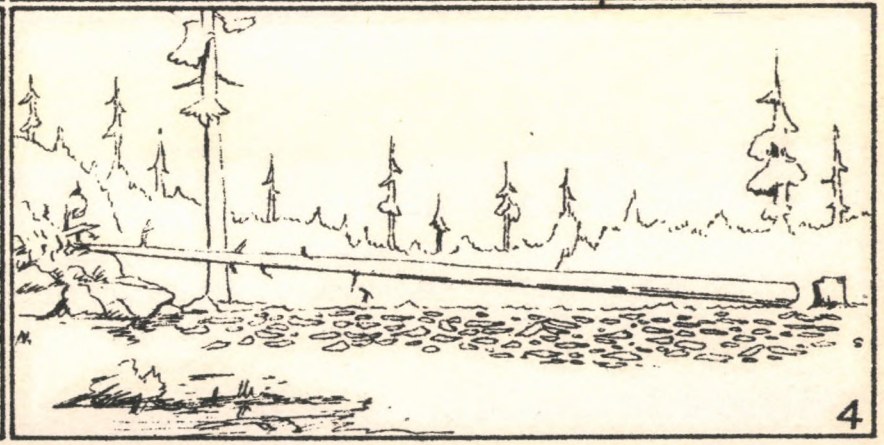
During the summer, the brood of the western pine beetle can be destroyed by the heat of the sun, if the air temperature is over 85° F. The infested trees are dropped on top of other logs when possible so that the bark from the under side can be removed. The infested bark is placed on the ground in direct sunlight, inner surface up. Only when the sun is very hot should the bark be spread on the top of the barked tree as air currents keep the bark much cooler than when it is on the ground.

PLATE 8









HINTS FOR BETTER SOLAR HEAT CONTROL-PONDEROSA PINE

Figure 1. A tree dropped over a small knoll so that the bark from the underside can be removed. The tree has been dropped north and south, and in order to get the quickest kill the bark has been spread out on the south side of the knoll where it is exposed to the most direct rays of the sun.

Figure 2. A tree dropped across a hollow, which also serves to keep it off the ground. The bark is again spread on the south exposure of the slope.

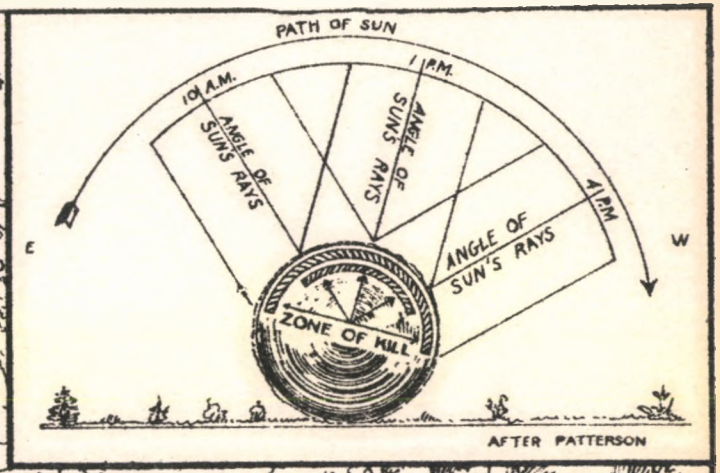
Figure 3. A tree lying flat on the ground. This is poor falling and should not be done if it can be avoided. The bark, as shown, should be placed so as not to be shaded by any nearby trees.

Figure 4. A tree dropped across a pile of rocks to keep the trunk off the ground. By careful planning such as shown or by placing larger limbs where a tree is to be fallen, one can usually drop the tree so that all or most of the bark on the underside can be removed without difficulty.

PLATE 9

SOLAR HEAT CONTROL-MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

When employing this method one should try to drop the full length of the log flat on the ground, in a north and south direction. The bark is left on as it is so thin that it gives but little protection to the brood from the heat of the sun. The upper side of the tree is left exposed to the sun for two days when it is rolled one-half over. When turned, a chip is taken out of the butt end, as shown, which indicates that the log has been turned. Note that the top is cut off at the end of infestation to facilitate rolling the log.



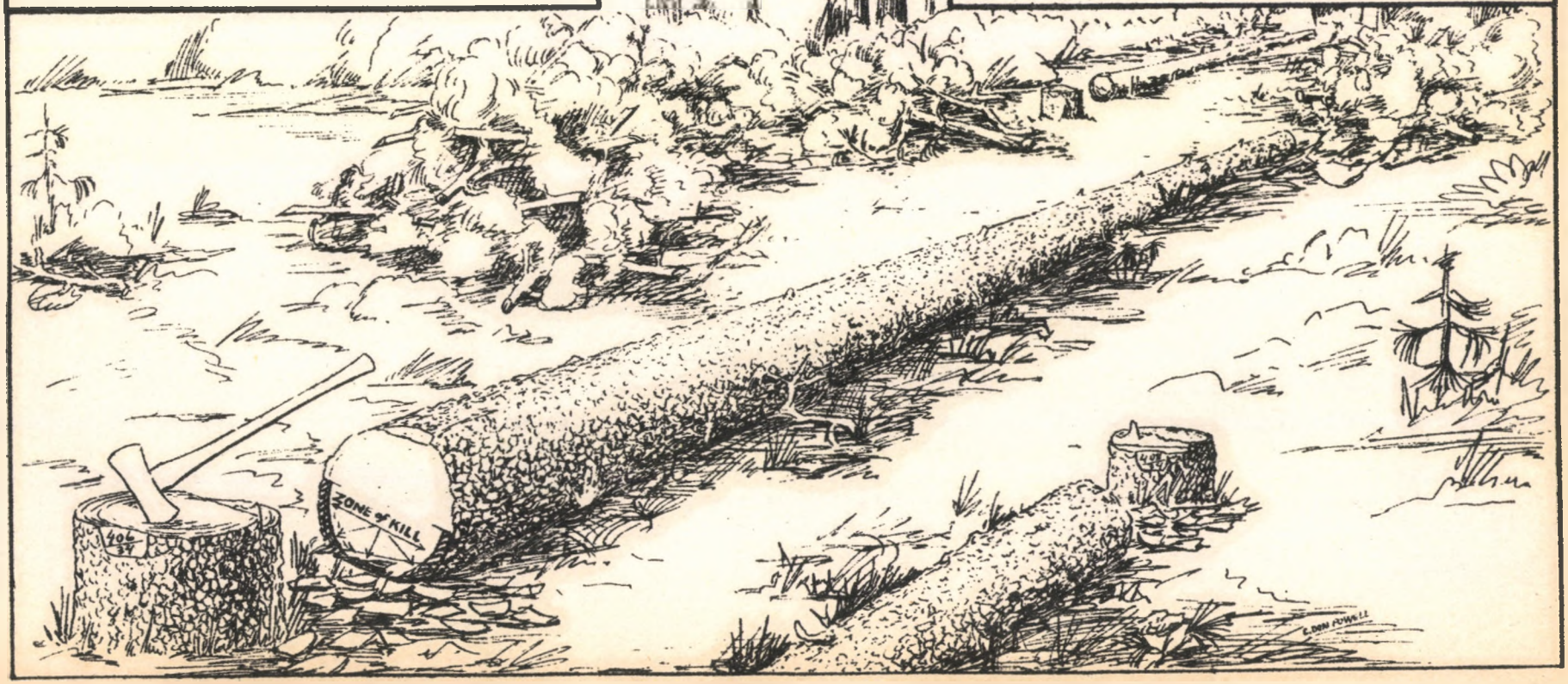
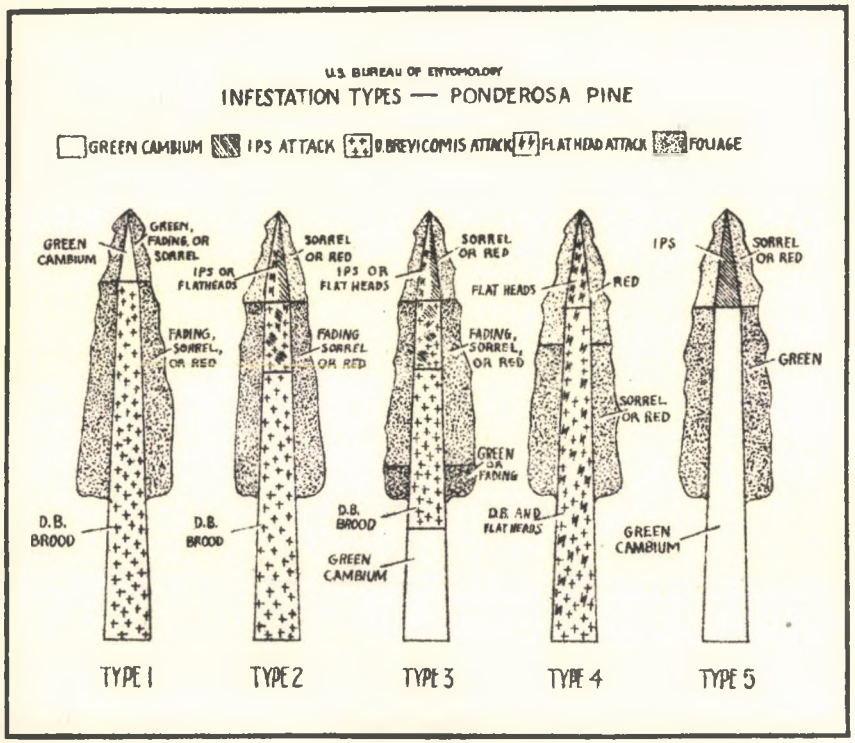
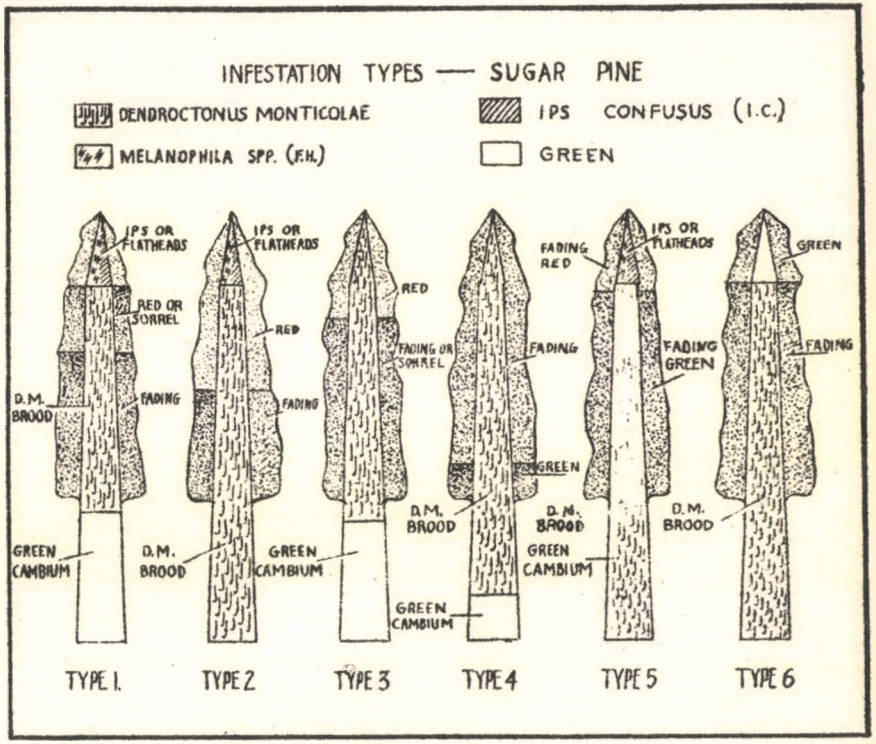


PLATE 10





The above diagrams show the variation of infestation in trees attacked by the beetles. It is these variations that frequently make spotting so difficult as the base may be green when there is brood in the trunk above, or there may be brood in the base but none or only a few beetles higher up. It often requires considerable experience to determine when a tree should be marked for treating and when it should be left unmarked. In both the ponderosa pine and sugar pine stands, Types 1 and 2 are the most common.

FOREST INSECT PROBLEMS

in

SEQUOIA NATIONAL PARK

(Including the History of Previous Control Projects, Barkbeetle Infestations, Methods of Control, Itemization of Control Projects, and Bibliography of Reports Dealing with Insect Outbreaks.)

Donald DeLeon*
Entomological Technician

Destructive forest insects have always been in our forests in small numbers, but at times, owing to the effects of a combination of factors not well understood, their numbers increase until millions of trees may be destroyed each season.

Since 1917 conditions seem to have been favorable, to a varying degree, for forest insect** outbreaks in Sequoia National Park. Because of a sudden increase in the number of dying Jeffrey, ponderosa, and sugar pine trees that year, J. M. Miller of the Bureau of Entomology and Ralph Hopping, then with the Forest Service, made what was the first survey in the Park to determine the actual losses. The results of this and subsequent surveys are discussed below.

PONDEROSA AND SUGAR PINE STANDS

A reconnaissance of the four major drainages on the west side of the park was made in this 1917 survey and heavy infestations requiring control work were found around Colony Mill and along the Middle Fork of the Kaweah River. The first treating to be done in the Park was begun in these two areas in the spring of 1918, when several hundred thousand board feet were treated. Control work, mainly of a maintenance character, was continued during 1919 and 1920 in the Marble Fork and Yucca Creek drainages. Following this three-year control campaign, the infestation subsided until 1928, when the western pine beetle began to kill off hundreds of trees on Milk Ranch Peak and along the East Fork of the Kaweah River.

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* Acknowledgment is made to Senior Entomologist J. M. Miller of the U. S. Bureau of Entomology and Plant Quarantine for material assistance in the preparation of this report.

** The following are the most important species: The western pine beetle in ponderosa pine; the mountain pine beetle in sugar, ponderosa, western white, and lodgepole pine; the Jeffrey pine beetle in Jeffrey pine; several species of Ips and two species of flatheads (Melanophila.)

A cruise of the Park made in 1930 by J. M. Miller of the Bureau of Entomology and Frank Been, then Park Naturalist, showed a loss that year of over 4,000 mature sugar and ponderosa pines. Control work was begun in the spring of 1931 in the Middle Fork and the Yucca Creek--Marble Fork drainages, where a total of 173 trees were treated. Because of adverse seasonal conditions and limited funds this program was inadequate and only a small part of this infested territory was covered. No treating was done during 1932, but in 1933, as the outbreak showed no signs of appreciable decrease, control work was carried out on an extensive scale, chiefly through the use of Civilian Conservation Corps labor. During this period 828 trees with a total volume of over a million board feet were treated.

Cruises made during the fall of 1933 over the entire ponderosa and sugar pine stands in the Park showed a loss of about 2,500 trees as compared with 4,000 in 1930. In 1934 about 1,000 trees were destroyed over the same area. Whether the decline will be permanent or not is difficult to say, but the results of the control work of the past indicate that if maintenance is continued each year the losses can be kept to a minimum in most of the areas.

Basing the estimate on figures secured since 1917, Sequoia National Park has lost over 24,000 mature sugar and ponderosa pines with a total volume of over 35½ million board feet during the past 18 years. There are on an average about 12 mature sugar or ponderosa pines to the acre; so that if all of the destroyed trees had been growing in a unit area there would now be about 2,000 acres of forest in Sequoia National Park containing nothing but dead trees and poles. A sample plot of about 100 acres was established in 1923 west of Atwell Mill and a cruise has been made each year since then of the plot to determine the annual losses. The figures for the losses between 1924 and 1928 are based on a cruise of trees that were judged to have died during this period. These cruises show that over the preceding decade (1924-1934) the total stand of timber over 12" D.B.H. on this plot has lost in volume 27 per cent of the ponderosa pine, and 11 per cent of the sugar pine, 13 per cent of the incense cedar, and 17 per cent of the white fir.

These figures show that actual losses over a relatively short period of time are considerable, and that the problem of dealing with destructive insects is a serious one.

THE PONDEROSA PINE PROBLEM

The Western pine beetle (Dendroctonus brevicomis) is responsible for the death of most of the ponderosa pine, though the mountain pine beetle (D. monticolae) also destroys a few of the smaller trees. The five-spined ponderosa pine engraver beetle (Ips confusus) top kills many trees, often making conditions favorable for successful attacks of either the western beetle or the flatheaded borers (Melanophila gentilis or M. californica.) The flatheads themselves are often primary, killing trees without aid from the bark beetles and attacking chiefly the middle and upper portions of the bole. The lower region of the tree then serves as a favorable breeding place for the western pine beetle, which is principally a lower bole

species; but when it is primary it leaves conditions suitable for the Ips and flathead attacks mentioned above, thus completing a vicious circle, as each species leaves breeding grounds for the other. With only one insect to control, the protection problem in the ponderosa pine stands would be relatively simple, but when there are the interlocking associations described above, actual spotting and treating are difficult.

THE SUGAR PINE PROBLEM

The mountain pine beetle (Dendroctonus monticolae) is the most important enemy of sugar pine trees but the five-spined ponderosa-pine engraver beetle (Ips confusus) and the pine flathead borer (Melanophila gentilis are also important factors. I. confusus attacks the tops of trees often preparing the way for a major attack by the mountain pine beetle. M. gentilis is more agressive and prefers the upper bole of large trees or makes a general attack on smaller trees. As there does not seem to be such a close relationship of these three beetles, control in the sugar pine stands is usually more simple.

JEFFREY PINE STANDS

The Jeffrey pine beetle is active in the Jeffrey pine along the General's Highway from Lodgepole Camp towards General Grant National Park, on the upper slopes of the Middle Fork and in River Valley. Though within the last few years it has become more active in these areas it is still not a serious pest. During control jogs in the ponderosa pine stands infested Jeffrey pine trees have been treated along with the other trees so that the infestation has been kept rather low. In 1929, however, a small outbreak occured in the Lodgepole Camp area. Twenty-three trees were treated and since then a small amount of maintenance work has been necessary to keep it down.

LODGEPOLE PINE STANDS

In the 1917 survey the lodgepole pine stands of Sequoia National Park were found to be comparatively free from the ravages of forest insects, no infestations of note being recorded. So far as can be determined, the mountain pine beetle began to increase in the lodgepole areas about 1924, and by 1928 an aggressive outbreak had built up in the mature stands of the Hockett Meadow region. Small centers had also formed at Lodgepole Camp, Willow Meadow, and Clover Creek. Control work was done at Lodgepole Camp in the fall of 1928, which immediately checked this outbreak. In 1929 and 1930 the Willow Meadow center was also cleaned up and since then these areas have been quite clean of mountain pine infestation.

Once the mountain pinebeetle becomes well established in a stand of lodgepole, it is difficult to control and treating has to be continued for several years before the effects of the work are noticeable. When the drop does occur, however, it is abrupt, and only a small amount of maintenance work isthereafter necessary. In the Hockett Meadow area the infestation contined to build up until in the spring of 1931 it was decided

to initiate control measures. Maintenance and an expansion of operations were necessary each year through the spring of 1934. Over this four-year period a total of 1522 trees, or an average of 380 trees a year were treated. Maintenance work was continued during the fall of 1934, but less than 100 infested trees could be located, so what was no doubt the beginning of a very serious epidemic was successfully headed off, but constant attention to the area must be given.

The results of the Clover Creek control project are similar. The first work was done in the fall of 1933 when 139 infested trees were treated; the following year 92 trees were treated, thus showing that the infestation had been materially reduced, but not as much as one would expect. It will probably require several more years of maintenance until the infestation is brought back to normal.

No cruises have been made in Kern River Canyon or Chagoopa Plateau but according to Ranger reports, the losses have been moderately heavy since 1928.

INCENSE CEDAR STANDS

There are considerable losses, especially of the smaller sized trees, from the attacks of the cedar bark beetle, Phloeosinus fulgens, and several other species of this group. In 1928-29 a very heavy killing by these insects occurred in the cedar pole stands above Paradise Creek. The larger trees are attacked by the round-headed amethyst borer, Semanotus amethystinus. They lay their eggs in apparently healthy trees and also dying ones and stumps.

No control work has ever been carried out against these insects and none will probably be needed, though at times they increase the fire hazard appreciably.

BIG TREE STANDS

The big tree is not immune to the attacks of insects, several species having been collected from green limbs or reared from recently fallen branches. Phloeosinus rubicundulus is a very common species in limbs that have fallen to the ground during the winter. Trachycele opulenta has also been collected from the trunk and bark but is a rather uncommon species. A heavy infestation of the Shasta scale, Aonidia shastae, was found in 1931 on the branches of small Big Trees growing along the Mineral King Road near Atwell Mill.

There are no records, however, of any insects causing the death of either young or mature big trees.

WHITE AND RED FIR STANDS

No control work has ever been conducted against the bark beetles infesting these two species of tree. Losses are wide-spread and often severe in stands of both reproduction and mature trees. The fir engraver

beetle (Scolytus ventralis) is the chief cause of these losses, though owing to its unusual habits no control measures are practicable aside from general sanitation work.

The fir engraver beetle is able to attack successfully a small portion of the bole of a tree and rear a brood without killing the tree. Consequently there is no way of telling when a tree is attacked unless the attacked area is close to the ground where it can be seen. The growing area destroyed by the brood of the beetle may then heal over so that after a period of years there will be no external evidence of the injury. At other times the beetles will attack and kill the top of a fir, which then sends up a lateral branch to take the place of the destroyed terminal,, thus giving a bayonet-like appearance to the upper end of the trunk. Firs with tops like this are com on through the forest. At other times the beetles will kill a group of small trees and at a distance the faded foliage appears to have been caused by a fire.

FOREST INSECT SURVEYS

In order to protect the forest properly it is important to know whether infestations are on the decline or increase, in just what area they are, and how much territory they cover. A series of surveys, necessary each year to secure this information is carried out by ranger districts, each district ranger then submitting a report of the results of his examinations. The proper way to conduct the surveys and the time of year for them have already been outlined and accompany the blanks when they are sent out each Fall to the district rangers for the tabulation of their findings.

These reports, however, deal with limited areas of the more noticeable outbreaks. Consequently it isimportant to have a knowledge of the losses or lack of losses for the park as a whole, which can be compared directly with losses of previous years. In order to secure this information, a system of topographic surveys for the sugar pine--ponderosa pine stands was inaugurated in the Fall of 1933. These surveys will be carried out each year, using the identical observation points for each region during each survey, with photographs also taken from the same pointsto show pictorially the actual conditions. The points of observation have been marked and are described in a report by the writer* so that whoever makes the survey will have little difficulty in locating these points.

BARK BEETLE CONTROL METHODS

During the past thirty years that bark beetle control projects have been carried on in the west methods employed have been gradually improved, refined, and standardized. The latest methods of control used today against the western pine beetle are excellently given in "The Control of the

* Report on the 1933 Losses of Sugar Pine and Ponderosa Pine in Sequoia National Park... July 1934.

Western Pine Beetle (Dendroctonus brevicomis)"**. The methods outlined in this bulletin can be used, for the most part, on any other bark beetle control project and should carefully be studied.

The following illustrations have been prepared to present graphically the principal methods that are used today on control projects.

For those who desire greater detail concerning insect control methods than is given in the accompanying drawings one should consult the mimeographed pamphlet "Insect Control Treating Instructions", prepared by Ranger-Forester Ernst of Yosemite National Park. Copies of these instructions are in Acting Forester's Office at Ash Mountain.

** A few copies are still available for distribution and may be secured by writing to the Branch of Forestry, U. P. S., 352 Hilgard Hall, Berkeley, California.

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Table 1, Summarizing the Insect Control Projects Carried Out
Since the First Project of 1918, Sequoia National Park

Location of Projects	Period Covered	No. of Acres Treated	Tree Species Treated	No. of Trees Treated	Board Feet Treated	Insect Controlled		Cost of Project
1) Yucca Creek--Marble Fork	5/21 to 6/10 1918	1500	Ponderosa P. Sugar Pine	12 45	44,520 182,810	Db* Dm**	1/1	600.50
2) Yucca Creek--Marble Fork	May to Oct. 1919	1000	Ponderosa P. Sugar Pine	26 44	50,960 125,780	Db Dm	1/1	330.00
3) Yucca Creek--Marble Fork	April to Oct. 1920	1000	Ponderosa P. Sugar Pine	12 22	32,660 111,630	Db Dm	1/1	300.00
4) Yucca Creek--Marble Fork	3/4 to 4/23 1931	1000	Ponderosa P. Sugar Pine	61 14	140,000	Db Dm	1/1	1494.90
5) Yucca Creek--Marble Fork	Spring, 1933	1920	Ponderosa P. Sugar Pine	254	419,250	Db Dm	1/1	2688.87
6) Yucca Creek--Marble Fork	Summer, 1933	1600	Ponderosa P. Sugar Pine	98	166,600	Db Dm	1/1	(appr 1000.00 CCC Proje
7) Yucca Creek--Marble Fork	March - April 1934	1920	Ponderosa P. Sugar Pine	98	174,890	Db Dm	1/1	1190.67 CCC Proje
8) Yucca Creek--Marble Fork	Summer, 1934	1920	Ponderosa P. Sugar Pine	105	230,210	Db Dm	1/1	1576.67 CCC Proje
9) Clover Creek	Fall, 1933	1380	Lodgepole P.	139	82,600	Dm		1072.23
10) Clover Creek	Fall 1934	1380	Lodgepole P.	92	53,940	Dm		883.69 CCC Proj

*Db - Western Pine Beetle **Dm - Mountain Pine Beetle ***Dj - Jeffrey Pine Beetle

Table 1, Summarizing the Insect Control Projects Carried Out Since the First Project of 1918, Sequoia National Park

(Continued)

Location of Projects	Period Covered	No. of Acres Treated	Tree Species Treated	No. of Trees Treated	Board Feet Treated	Insect Controlled	Cost of Project
11) Middle Fork of Kaweah Cliff Creek River Valley Granite Creek Buck Canyon Mehrten Creek	4/1 to 5/20 1918	4000	Ponderosa Pine Sugar Pine Jeffrey Pine	87 45 1	209,580 169,020 4,100	Db* Dm** Dj***	$ 1580.60
12) Middle Fork Mehrten Creek	3/17 to 4/18 1931	800	Ponderosa Pine Sugar Pine	97	150,000	Db Dm	2012.15
13) Middle Fork of Kaweah River Valley Granite Creek Buck Canyon	Oct. Nov.-'34	800	Ponderosa Pine Jeffrey Pine Sugar Pine	44	51,520	Db Dj	1025.21
Mehrten Creek Panther Creek	Nov.-Dec.-'34	2500	Ponderosa Pine Sugar Pine Jeffrey Pine	101	124,450	Dm	(CCC Proj 3249.43
14) East Fork of Kaweah Atwell Mill	Oct., Nov., Dec., 1934	1200	Ponderosa Pine Sugar Pine	128	192,180	Db Dm	2745.36 (CCC Proj
15) Lodgepole Camp	Oct. 1928	500	Lodgepole Pine	43	36,660	Dm	280.00 (est.
16) Lodgepole Camp	10/16-10/31 & 12/6-12/10-'29	500	Jeffrey Pine Lodgepole Pine	23 4	[illegible] [illegible]	Dj Dm	215.00

*Db - Western Pine Beetle **Dm - Mountain Pine Beetle ***Jeffrey Pine Beetle

Table 1, Summarizing the Insect Control Projects Carried Out Since the First Project of 1918, Sequoia National Park

(Continued)

Location of Projects	Period Covered	No. of Acres Treated	Tree Species Treated	No. of Trees Treated	Board Feet Treated	Insect Controlled	Cost of Project
17) Willow Meadow Lodgepole Camp Giant Forest Camp	Oct.2-23,'30	1000	Lodgepole P. Jeffrey Pine Sugar Pine	41 56 4	35,420 67,200 8,000	Db* Dj*** Dm**	$ 475.20
18) Horse Creek Hockett Meadow	May 1-22,'31	1050	Lodgepole Pine Mountain Pine	286 4	178,870	Dm	1083.75
19) Horse Creek Hockett Meadow	Spring, 1932	1050	Lodgepole Pine	312	193,440	Dm	1559.65
20) Horse Creek Hockett Meadow	Fall, 1932	1050	Lodgepole Pine	165	78,050	Dm	433.24
21) Horse Creek Hockett Meadow	Oct.-Nov.'33	2000	Lodgepole Pine Mountain Pine	336 2	136,810 2,000	Dm	2373.34
22) Horse Creek Hockett Meadow	May-June 1934	1000	Mountain Pine	286	189,080	Dm	2391.23 (CCC Project
23) Horse Creek Hockett Meadow	November 1934	1000	Lodgepole Pine	73	29,550	Dm	1074.83 (CCC Project
TOTALS:		33,070		3,160	3,704,860		$31,636.52

*Db - Western Pine Beetle **Dm - Mountain Pine Beetle ***Dj - Jeffrey Pine Beetle